KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

*LONDON: MARCH* 1, 1890.

## CONTENTS.

**Egg-laying Mammals.** By R. Lydekker, B.A.Cantab. ... 83
**Influence Machines.** By R. Camper Day, B.A.Oxon. ... 86
**House-flies and Bluebottles.** By E. A. Butler ... ... 89
**Where was the Aryan Cradle first Rocked?** By Edward Clodd ... ... ... ... ... ... ... ... 91
**Variable Stars.** By A. C. Ranyard and C. E. Peek ... 93
**Weighing a Double Star** ... ... ... ... ... 96
**Notices of Books** ... ... ... ... ... ... ... 97
**Letters:**—W. H. S. Monck, T. S. Barrett, J. S., G. C. G., John Kenny ... ... ... ... .. ... ... 98
**The Face of the Sky for March.** By Herbert Sadler, F.R.A.S. ... ... ... ... ... ... 99
**Whist Column.** By W. Montagu Gattie ... ... ... 100
**Chess Column.** By W. Montagu Gattie ... ... ... 101

## EGG-LAYING MAMMALS.

By R. Lydekker, B.A.Cantab.

UNTIL quite recently it was an axiom in Zoology that Mammals (or, as they were often termed, Quadrupeds) were broadly distinguished from Birds and Reptiles by the circumstance that their young were born into the world in a living condition; whereas in the two latter groups the young were developed from eggs laid by the parent, although in a few Reptiles their eggs were hatched within the body of the parent itself. Within the last few years, however, it has been found that two most remarkable Mammals confined to the Australasian region differ from all other members of the same great class, and resemble Birds and Reptiles in that they actually lay true eggs from which the living young are in due course hatched. This remarkable discovery has shown that the animals in question are more widely separated from all other existing Mammals than had previously been considered to be the case; and since we have in late years become acquainted with an extinct group of fossil reptiles which show some remarkable signs of affinities with these egg-laying, or oviparous Mammals, our ideas of the mutual relationships of Mammals and Reptiles have undergone a very considerable change.

Before proceeding further, it will be necessary that we should become acquainted with the names and external features of these peculiar and aberrant types of mammalian life, which have fortunately been preserved to us among many other strange forms peculiar to the Australasian region, and thus enable us to trace, however imperfectly, the connection which seems once to have existed between Mammals and Reptiles. The most peculiar in external appearance of these two mammals is the one commonly known as the Duck-bill, and scientifically as the *Ornithorhynchus anatinus*, of which a figure (from the late Mr. Waterhouse's memoir in *Jardine's Natural History*) is given in the accompanying woodcut (Fig. 1). The most striking feature about this strange animal is the presence of the duck-like horny beak ensheathing the mouth, from which the creature takes both its popular and scientific names; and which, when skins were first brought to Europe, was deemed so extraordinary as to give rise to a suspicion that the specimens were "made up," after the fashion of the well-known monstrous animals of the Japanese. Peculiar as the beak undoubtedly is, it is not, however, of primary interest, since it is one of those structures which naturalists term acquired features, and is not inherited from very remote antiquity; so that there is no sort of connection between this beak and the beak of a bird, beyond the fact that both are used for the same purpose. The Duck-bill has a total length of about 23 inches, of which $2\frac{1}{2}$ are formed by the beak, and 5 by the tail. The body is covered with a thick coat of fur, which is generally of a full umber-brown colour, inclining either to rufous or to black in different individuals; the underparts and a ring round the eye being yellowish, or greyish white. The tail is broad and flat, and is thus well adapted to act as a rudder in swimming; while the feet are fully webbed, and thus at once proclaim the aquatic habits of the creature. The beak is black above, and yellow and black below. The limbs are remarkable for their shortness, their length being insufficient to keep the body from touching the ground.

In the adult animal there are no teeth in the jaws, their function being performed by a few hard and flat horny plates, aided by the horny edges of the jaws themselves. In young individuals there are, however, a small number of well-developed teeth in the hinder half of each jaw, which fall out before the animal attains its full dimensions. The structure of these teeth is unlike that found in any other living mammal; the chief peculiarity being the presence of a groove running from back to front, and bordered by ridges bearing cusps on either side. The presence of these deciduous teeth has only very recently been made known (thus showing, by the way, how very imperfect our knowledge still is of many comparatively common animals); and we may safely infer that the ancestors of the Duck-bill were provided with a full set of permanent teeth, which have gradually tended to disappear. This rudimentary condition of the teeth in the Duck-bill is indeed another instance of that tendency to the loss of the teeth in certain groups of animals to which allusion has been made in an article by the present writer published in the January number of this serial; and the complete loss of the teeth occurs in the second representation of the present group, to be noticed immediately.

The Duck-bill chiefly frequents the still and open pools, thickly covered with aquatic plants, which are of common occurrence in the Australian rivers. In the banks of these pools the burrows of these creatures are constructed; their entrance being concealed among the water-plants, and frequently opening some distance below the level of the water. From the entrance the burrow takes an upward direction in a somewhat serpentine course, and may run for a distance of some 20 feet before it ends in a chamber situated far above the level of the water, and lined with dry grass. In this chamber, which may have a diameter of some 18 inches, the eggs are laid, and the young in due course hatched therefrom. The young when first hatched are entirely naked, and their beak is soft and fleshy, so that it can be readily applied to the milk-glands

of the mother, which merely open on the surface of the body, and are not provided with nipples. This feature of the nurturing of the young by milk-glands, in spite of the peculiarities of internal structure which we shall allude to later on, and the oviparous reproduction, at once proclaims that the Duck-bill is a true mammal, although a very lowly representative of the class.

The second representation of the group includes the Spiny Anteaters (*Echidna*), of which one species occurs in Australia and New Guinea, and a second and larger one only in New Guinea. A figure of the Australian species is given in woodcut 2.

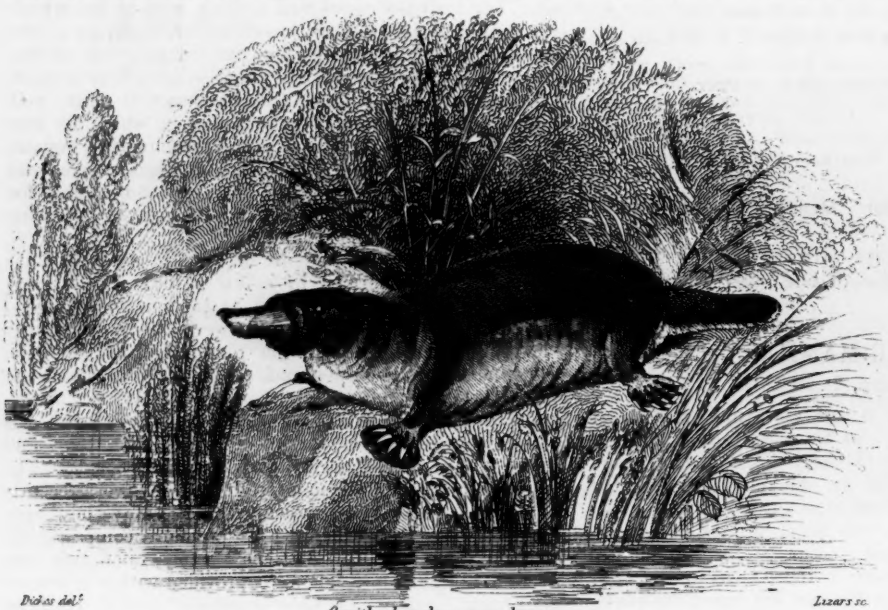
From the appearance of this animal in the figure, there would seem to be but little ground for classifying it in the same group as the Duck-bill; and it is mainly from the evidence of the peculiar internal structure that the two are put together in the zoological system. The skull, in place of the expanded beak of the Duck-bill, has a long slender cylindrical beak, covered with horn, and with the nostrils at the extremity. There are no traces of teeth at any stage of existence; and the tongue is very long and slender, and capable of being protruded for a considerable distance from the mouth, to collect the ants on which the creature feeds. The fur is more or less thickly intermingled with stout spikes, like those of a hedgehog; the tail is rudimentary; and the short limbs are furnished with stout and extremely powerful claws, which may be either three or five in number.

In calling these animals Anteaters the reader will, of course, bear in mind that they have nothing whatever to do with the true Anteaters of South America, which belong to the so-called Edentate order of Mammals; and that they are equally distinct from the Banded Anteater of Australia, which belongs to the Pouched or Marsupial Mammals. In view of this similarity of names it will perhaps be better if the Latin term Echidna be taken as the popular as well as the scientific name of the Spiny Anteaters.

The Australian Echidna is characterized by having five claws to each foot, and is subject to considerable variation in size and colour, and also as to the relative abundance of spines in the fur. The New Guinea, or Three-toed Echidna, is larger than many specimens of the common species, and usually has but three claws to each foot.

Echidnas are usually found in rocky and mountainous districts, and are of nocturnal and burrowing habits; their powerful claws enabling them to bury themselves in the ground with extraordinary rapidity. If dug out from their burrows during the day, they appear to be very sluggish and stupid, crouching to the ground with the head between the legs, and thus presenting a mass of spines to an enemy. Although their food consists mainly of ants, it has been asserted that Echidnas also eat grass and other plants. The eggs of the Echidna have, indeed, been found and described; but it appears that the development of the young is less well known than in the case of the Duck-bill.

Having now introduced our readers to the personal appearance and habits of the Duck-bill and the Echidna, we are in a position to enter into the consideration—very brief and simple though this must necessarily be—of some of the more striking features of their structure, and of their relationship to other groups of animals.




*Ornithorhynchus paradoxus.*

Native of New South Wales

Fig. 1. The Duck-bill of Australia. From *Jardine's Natural History.*

We have already stated that these creatures agree with other mammals in suckling their young from milk-glands on the body of the female parent, and are therefore rightly included in the great class of Mammals. They also agree with other mammals in that the skull articulates with the first joint of the backbone, or first vertebra, by means of two knob-like prominences known as *condyles*. In this respect they differ from Birds and Reptiles, in which this articulation takes place only by a single condyle; but it is very noteworthy that two condyles are found in the Amphibians (Frogs, Newts, &c.). In their warm blood these creatures also agree with other mammals; but this is a feature of no importance from a classificatory point of view, since it is found in Birds and Mammals which we must regard as being independently derived from cold-blooded animals. Again, although the Duck-bill and the Echidna, as necessarily follows from their warm blood, have a four-chambered heart like all other mammals, yet it is most noteworthy that the heart contains certain peculiarities connecting it in some degree with the three-chambered heart of Reptiles. These animals differ, however, from all other mammals in that the tubes for carrying off the waste products of the body have but a single common aperture, precisely as in Birds and Reptiles, and are therefore generally described as the Monotremes, or Monotremata, by which name we shall henceforth refer to them.

Two other remarkable peculiarities connected with the skeleton require notice in some detail. Exclusive of the Monotremes, all mammals, without exception, have only two bones on either side of the body, by means of which the arm is connected with the trunk, and which are collectively spoken of as the shoulder-girdle. These bones are respectively the shoulder-blade at the back, and the collar-bone in front; the head of the arm-bone being received into a cup-like cavity in the lower end of the shoulder-blade. Now in the Monotremes we find, in addition to the shoulder-blade, a smaller bone known as the coracoid-bone, which forms part of the cavity for the head of the arm-bone, precisely as in the reptilian shoulder-girdle represented in Fig. 3. Further, in advance of the coracoid-bone, and below the shoulder-blade, the Monotremes have a third bone in the part of the shoulder-girdle corresponding to the one marked *p. cor.* in Fig. 3, and which should likewise be known as the precoracoid, although it is often termed the epicoracoid. We thus see that in this part of their shoulder-girdle the Monotremes are totally unlike all other mammals, and resemble that extinct group of Reptiles of which this part of the skeleton is shown in the woodcut. A further resemblance to Reptiles is, however, indicated by the presence of a peculiar T-shaped bone lying on the front of the chest between the collar-bones or clavicles, and hence termed the interclavicle; this interclavicle occurring not only in that group of Reptiles to which the figured shoulder-girdle belongs, but also in Lizards, Fish-Lizards,* and other types.

Fig. 2.—The Spiny Anteater of Australia (*Echidna aculeata*). From *Jardine's Natural History.*

With regard to the type of shoulder-girdle represented in Fig. 3, it should be observed that in all existing Reptiles the precoracoid (*p. cor.*) becomes united either with the coracoid or the shoulder-blade, so that in many cases it cannot even be recognised as a distinct element at all. The same is the case with all extinct groups of Reptiles, with the sole exception of one very remarkable group found in the early Mesozoic rocks of South Africa, India, North America, and parts of Russia, and known, from their peculiar types of teeth, as the Anomodonts, or Anomodontia. In Amphibians (Frogs, &c.) there is, however, likewise a distinct precoracoid, which in some extinct types not improbably approximated to the form shown in Fig. 3; although in frogs the precoracoid forms a simple rod-like bone.

We find, therefore, that the only known animals possessing both a coracoid and a precoracoid as separate elements distinct from the shoulder-blade† are the Monotreme Mammals, the Anomodont Reptiles, and the Amphibians; and since we have shown that in other respects the Monotremes are to a considerable extent intermediate between Reptiles and other Mammals, there arises a strong presumption that the Echidna and the Duck-bill are the last remnants of a group of animals which were veritable connecting links between Mammals, Reptiles, and Amphibians. Now among the Anomodont Reptiles — and in these alone among the whole class — we find in many cases that the jaws were armed with teeth which were arranged in three groups corresponding to the incisive, or front teeth, the tusks, or eye-teeth, and the grinding teeth, of Mammals; so that we have here another indication of the affinity of this group with the latter. Another remarkable peculiarity of the Anomodonts is that the perforation in the lower end of the bone of the upper arm is situated on the inner side—or side corresponding to the little finger—as in Monotremes and many other mammals (as the Cat); whereas in most other reptiles this perforation is situated on the outer side—or side corresponding to the thumb. The upper arm-bone itself of the Anomodonts is also wonderfully like that of Monotremes.

There are, indeed, many other features into the consideration of which it would be quite out of place to enter in this article which also lead to the same conclusion. We must, however, remember that Anomodonts agree with all other reptiles in having only one condyle by which the skull articulates with the back-bone; and this difference may be a bar to regarding them as the direct ancestral types of Mammals. Certain extinct Amphibians known as Labyrinthodonts, in which there were two condyles to the skull, are, however, so closely allied to the Anomodonts that it is in some instances difficult to draw a line of distinction between the two; and we may,

* *See* Knowledge for November 1889.

† In adult Monotremes the coracoid unites by bone with the shoulder-blade.

therefore, venture to affirm that Labyrinthodont amphibians, Anomodont Reptiles, and Monotreme Mammals have all taken origin from one common amphibian stock; the Anomodonts retaining marked evidences of their kinship to the Mammals which have been totally lost in all other reptiles.

Fig. 3.—The Right Side of Part of the Shoulder-Girdle of an Anomodont Reptile. *sc.* shoulder-blade; *ab* processes of do.; *cor.* coracoid bone; *p. cor.* precoracoid bone; *gl.* cavity for head of arm-bone. The shaded portion is from an Indian and the unshaded from an African specimen.

Such, then, is very briefly the chief deductions which can be drawn from the life-history and structure of the Duck-bill and Echidna as to their affinities with other groups of animals; and it is curious to reflect that but for the preservation in a remote part of the world of these two representatives of a group which must in all probability have been once abundant, we should have been utterly unable to trace this wonderful relationship of the higher mammals to the earlier types of reptiles and amphibians.

At present we have, indeed, no absolutely conclusive evidence of the former existence of mammals allied to the living Monotremes, although there is a certain amount of evidence tending in this direction. Thus in the Mesozoic rocks, dating from the Trias to the Chalk, and also in the lowest beds of the overlying Tertiary, we meet with a number of small mammals characterized by a very peculiar type of grinding teeth. These teeth (Fig. 4) consist of two or three longitudinal ridges carrying distinct cusps, and separated from one another by deep grooves, which may be either one or two in number. This type of tooth is quite unlike that found in any of the higher mammals, but it does present a certain approximation to the deciduous teeth of the Duck-bill; so that it is not improbable that in this group of extinct mammals we may really have forms allied to the ancestral Monotremes. Some further evidence in favour of this view has, indeed, been recently published in the United States, where certain bones of these mammals have been described as the coracoid and interclavicle —an interpretation which, if correct, will prove their affinity to the Monotremes. For the present we must, however, wait in the confident expectation that future discoveries will some day reveal to us the remains of extinct animals allied on the one hand to the existing Monotremes, and on the other so closely connected with the Anomodont reptiles and the Labyrinthodont amphibians as to render it very difficult to give a definition of either mammals, reptiles, or amphibians.

Fig. 4.—Views of a Tooth of a small Mammal (*Tritylodon*), from the Lower Mesozoic Rocks of Stuttgart. The two central figures are of the natural size, and the others enlarged; *o* is the surface used for mastication.

## INFLUENCE MACHINES.

By R. Camper Day, B.A.Oxon.

During the last few years electricians have been devoting much attention to what is known as the "Influence machine," and several improved forms of it have been brought to a high state of perfection. Everybody knows the "frictional" electrical machine, with its revolving cylinder or disc of glass, against which a pad of greased silk, dusted over with amalgam, is made to press, and its toothed comb, by which the electricity is collected from the cylinder and stored in a "conductor." In the less known but far more ingenious "influence" machine a different principle is applied. The electricity generated by the frictional machine is static, and so also is that generated by the influence machine. In both machines there are revolving glass discs. Here, however, the resemblance ends. In the influence machine there is no friction; the electricity is generated, not by the pressure of a silk pad, but simply by what is known as induction or influence. The action of the influence machine, like that of the frictional machine, is quite easy to understand, and demands no knowledge of electricity beyond an acquaintance with the elementary experiments which are found in the opening chapters of every text-book. It cannot be said, of course, that the nature of electricity and the way in which it exerts what is called "influence" are easy to understand; but these are questions into which we need not enter at present.

In order that the principle of "influence" may be readily grasped, let us refresh our memory of one of the elementary experiments above referred to. The common gold-leaf electroscope, it is well known, consists of two small pieces of gold-leaf suspended inside a glass bell-jar. The pieces of gold-leaf are connected by a short wire with the flat disc of metal at the top of the instrument. If a rod of glass which has been rubbed with dry silk, and thereby charged with positive electricity, be held over the disc what happens? Before the glass rod is brought near there are no signs of electricity in the electroscope: it is convenient, however, to suppose that in reality it contains two equal charges of positive and negative electricity; but these two charges neutralise each other, and consequently the electroscope behaves as if it had no electricity in it, The approach of the glass rod, with its load of positive electricity, alters matters entirely. By its "influence" it causes the two charges in the electroscope to separate. It attracts the negative into the disc, and it repels the positive into the gold-leaves; for it is a fundamental principle that like electricities repel, and unlike attract one another. The gold-leaves, being both filled with positive electricity, forthwith become self-repellent and diverge widely. The state of the electroscope when under the influence of the charged rod is shown in Fig. 1.

If while matters are at this stage the disc is touched with a finger, what happens? The negative electricity still remains in the disc, held fast by the attraction of the glass rod, but the positive electricity of the gold-leaves instantly disappears. It has run away through your finger and your body to the earth. The gold-leaves consequently collapse. If after removing your finger from the disc you take away the glass rod, the leaves will again diverge, this

time with negative electricity. The electroscope *has been negatively charged by the simple process of touching the disc while under the influence of positive electricity.* The effect of the touch was, in brief, to remove a portion of the positive charge which was neutralising the equal negative charge when the experiment was begun, so that there is now in the instrument a preponderance of negative electricity.

One more experiment will place us in a position to understand the whole principle of the influence machine.

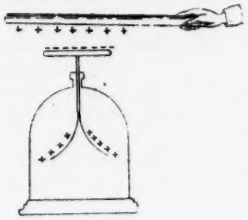


Fig. 1.

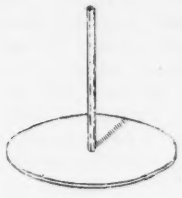


Fig. 2.

If we take off the disc of the electroscope and affix a glass handle to it, we have what Volta called an "electrophorus," or carrier of electricity (Fig. 2). We shall also require two similar but larger discs, B and C, each arranged so as to stand on a glass pillar (Fig. 3). With this apparatus we can produce a remarkable effect. The first step is to hold the electrophorus A close to a rubbed glass rod, and touch it as shown in Fig. 4. A is then charged with negative electricity, and C may be charged in a similar manner. The glass rod will no longer be

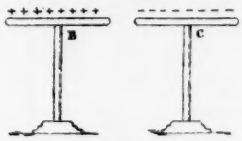



Fig. 3.

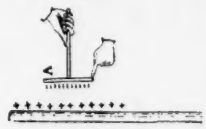


Fig. 4.

required, and may be removed. If now we hold A over B, and touch B, B acquires a positive charge; the negative charge on A is the same as before, for A is insulated, and we have been careful not to touch it since it was charged. But now we cause A to touch C on the under side, and when the two are in contact let B be inserted, held over C, and touched while under the influence of the joint charges. It receives a positive charge nearly equal to the two negative charges. Let A be removed, and then let B with its augmented positive charge be restored to its original position. Then A can be again held over B and touched. It receives a larger negative charge than before. When, therefore, we proceed once more to touch C with A on the under side, and to suspend B over C, then B on being touched will receive a positive charge nearly twice as great as that which it received when last it was held over C. The process may be continued *ad libitum*, and at every step the charges in B and C will be increased. This was the principle of the "doubler" invented by the Rev. Abraham Bennet in 1787.

The influence machine is a contrivance by means of which the operation of bringing one plate into the neighbourhood of another and touching it while under influence is performed mechanically. About the year 1788 William Nicholson devised an instrument, also called a "doubler," in which there were two fixed plates; a third was attached to the end of a revolving arm of glass. At every revolution of the arm, which was turned by a handle, one plate was brought opposite to each of the others in turn, and the revolving plate and one of the stationary plates were alternately put in contact with a large metallic ball. The necessary touching was effected at the right moment by small metallic springs. Nicholson's doubler was the first rotatory influence machine, and was the parent of the beautiful instruments of to-day.

Since his time, however, some very important advances have been made, the chief of which is the special development of what is known as the "reciprocal" principle. This principle, as Prof. Silvanus Thompson tells us, was first applied by G. Belli, an Italian, who, in 1831, described the apparatus of which a sketch is given in Fig. 5.*

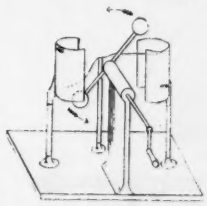


Fig. 5.

Supported on glass pillars are two half-cylinders of metal. Attached to a rotating handle are two arms of glass, each of which carries at its extremity a small metal disc. At the back is a pillar (not necessarily insulating) which carries a piece of wire. One end of the wire projects (without touching) into the lower part of the left half-cylinder, and the other end into the upper part of the right half-cylinder. The two small discs, as they rotate in the direction of the arrows, touch the opposite ends of the wire simultaneously just before they begin to emerge from the half-cylinders, and are therefore momentarily placed in electrical contact with one another. Half a revolution later, just as they are *entering* the half-cylinders, they touch the two small spiral springs shown in the figure. Let us now impart a slight positive charge to the right-hand half-cylinder, turn the handle, and observe the effect. As one of the discs emerges from the charged half-cylinder it is touched by the wire, and consequently becomes negatively electrified. It carries its negative charge over to the other side, and gives it up by touching the spiral spring in the left half-cylinder. The two half-cylinders are now both charged, the right positively and the left negatively. Proceeding onwards, the disc acquires a positive charge when it next touches the wire just before leaving the left half-cylinder, and this charge it afterwards gives up to the right half-cylinder. Thus the charges in the two half-cylinders are continually augmented, and as they grow they cause larger and larger charges to be carried by the discs, so that, as Prof. Thompson has pointed out, the charges may be said to accumulate at compound interest.

Of the many ingenious influence machines which embody the principle of Belli's Doubler, it must suffice to enumerate Sir William Thomson's "Mouse Mill" and "Replenisher," Clarke's Gas-lighter, Varley's machine, and the Voss-Toepler machine. About 1867, Holtz, who had previously distinguished himself in the same department of research, struck out a new line by constructing an influence machine which consisted of two discs of glass revolving about the same axis in opposite directions. But it was reserved for Mr. James Wimshurst to take the final step, so far as the evolution of influence machines has proceeded at present, by combining in one improved instrument the advantages of Holtz's revolving discs and Belli's metallic carriers. When he did this he was not aware of the fact that in Holtz's later machines both of the discs are made to rotate. The Wimshurst machine, of which a drawing is given in Fig. 6, consists of two glass discs re-

* From Prof. Thompson's paper in the *Journal* of the Institution of Electrical Engineers.

volving in opposite directions on the same axis. On the outside of each disc sixteen metallic carriers, called "sectors," are mounted. A curved brass rod with metallic brushes at each end, which lightly touch the opposite sectors of the front disc, is fixed to the upright which carries the axis of the disc, and, as shown in the figure, crosses the disc diagonally downward from left to right in front of the instrument. A similar rod, at right angles to this one, may be seen through the glass discs at the back of the instrument. On each side is a pair of collecting combs, the teeth of which nearly touch the sectors as they pass. When the

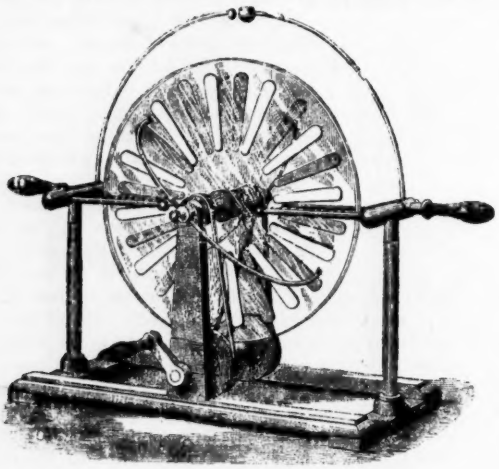


Fig. 6.

handle is put in motion positive electricity is collected by one set of combs and negative by the other, and sparks immediately begin to fly between the two discharging knobs shown at the top of the instrument. The distance between these knobs can be regulated by means of the two handles projecting right and left on either side; and it is usual, in order to increase the effect, to connect the two knobs to two Leyden jars. There is no distinction here, as in Belli's machine, between the "carriers" and half-cylinders or "field plates" as Professor Thompson calls them. The sectors on each disc fulfil both functions in turn.

Professor Thompson has invented a diagram, reproduced in a slightly altered form in Fig. 7, from which it is easy to obtain a clear idea of the way in which the machine works. The sectors are arranged in two circles. For convenience sake, one circle is shown inside the other. The shaded sectors are negative and the plain ones positive; and the positive or negative charge on each sector is further indicated by the (+) or minus (−) sign. Between the inner and outer sets there are of course two thicknesses of glass. The two sets go round in opposite directions, as shown by the arrows.

"Consider the carrier (at A) on the back (or outer) set, positively charged and situated on the left at 45 degrees above the horizontal diameter," says Professor Thompson. "Opposite this positively charged sector there is a metallic sector (B) in the front (or inner) set, going across from left to right. As it passes it comes into contact with a brush of fine wires on the end of a diagonal conductor. This neutralising brush touches it while under influence. As a consequence electric displacement will occur across the dielectric at that point, and the metal sector will become negatively charged, some electricity flowing out of it down the diagonal conductor. As all the front (inner) sectors pass this point they go on, over the top, negatively charged; whilst for precisely analogous reasons the back (outer) sectors behind them come over the top from right to left positively charged; they have been touched by the other neutralising brush while under the influence of the negative charges on the front (inner) sectors. The sectors of each set, while acting as carriers of their own respective charges, act also as field-plates to influence the sectors of the other set. Further, while the positively and negatively charged carriers are passing one another their charges attract one another, and there would occur sparks across between them if it were not for the plates of glass which separate them. As each carrier comes up to be touched by the neutralising brush, there will be a rush of electricity between the two ends of the diagonal conductor, where similar actions, but of opposite sign, are taking place. I have drawn my diagram as though each (back) carrier coming over the top from right to left brought six

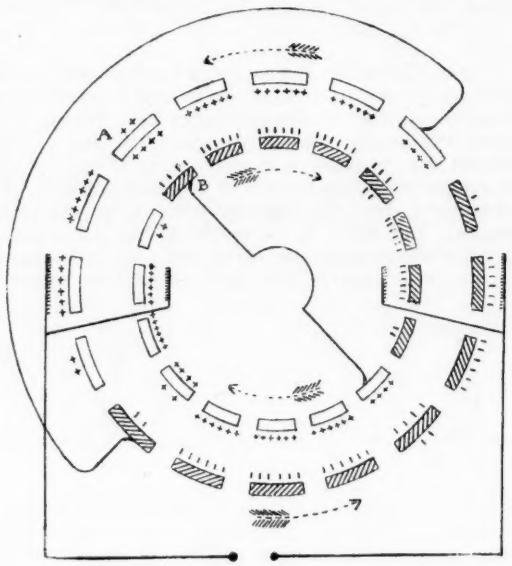
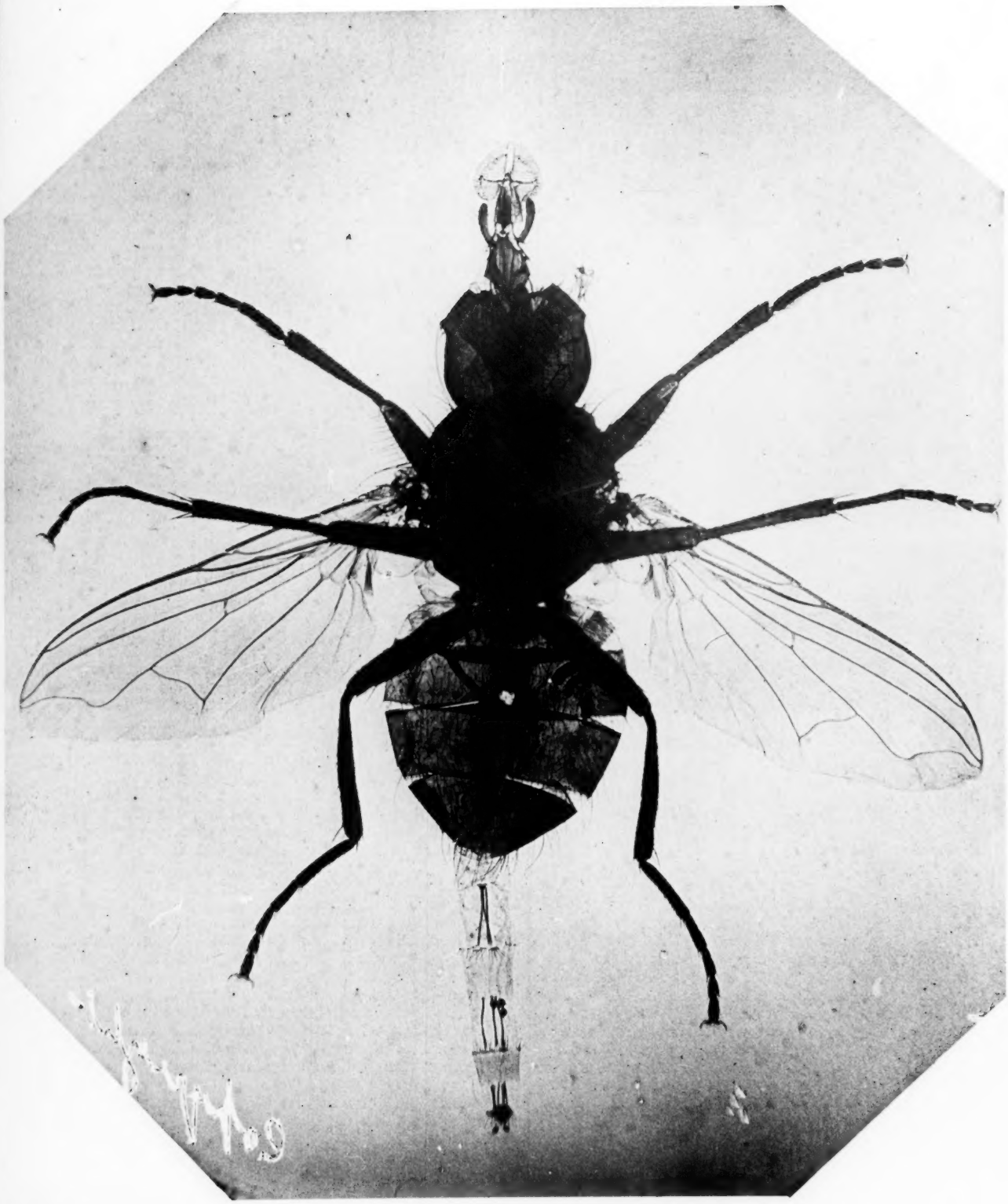



Fig. 7.

units of positive charge. Each carrier of the front (inner) set, as it passes under the neutralising brush at 45 degrees above the horizontal on the left, is considered as having electricity driven out of it by the influence of these positive charges, and as being left in a state of negative charge to the amount of six negative units. In the lower half of the machine similar actions are going on, with the result that the positive charges are brought to the left side of the machine by both discs, whilst negative charges are brought by both discs to the right side."

To this concise description it is only needful to add that with the Wimshurst machine it is not necessary to impart a small initial charge to any of the carriers or to any part of the instrument. When the number of sectors is not less than sixteen on each disc, the machine if properly adjusted will excite itself without fail, the reason being that among so many small insulated pieces of metal there must almost inevitably be slight differences of electric potential at all times, and any such slight differences are rapidly multiplied to sensible proportion by the cumulative action of the apparatus. Moreover, the Wimshurst machine, unlike the frictional machines, is not thrown out of work by a slight dampness of the atmo-

XUM



**HOUSE-FLY** (*Musca Domestica*).

Photographed from the under side, with Tongue and Ovipositor extended. Magnified about 16 diameters.

Photo-Plate Engr. Co., Limited, 9 Barnsbury Park, N.

XUM

phere. A machine suddenly brought from a cold room to a warm one may fail for a few minutes, in consequence of the condensation of moisture on the glass, but as soon as it attains the temperature of the room it will be restored to working order. As the machine is easy to make and the materials cheap, it is very popular with amateur workers; and it is well worth making when we consider the beautiful and striking effects that can unfailingly be produced by it.

## HOUSE-FLIES AND BLUEBOTTLES.—I.

By E. A. Butler.

THE swarms of flies which in the summer months invade our houses, and disturb our peace both of mind and body, are of several different kinds. Popularly, the smaller species are usually called indiscriminately "house-flies,"or, indeed, simply "flies," and the larger ones "bluebottles," whereby names that, strictly speaking, belong to certain species only, are vaguely used for a variety of forms more or less distinct. In our title we have deferred to popular usage, and intend to include under these two well-known names all members of the family *Muscidæ* that render themselves obnoxious to us in our indoor life, either by their persecution of our persons or their raids on our belongings. At the outset, therefore, it may be as well to make some attempt at discriminating species, that we may know exactly what insects we are talking about.

The *Muscidæ* are an enormously large and very puzzling family of the two-winged flies, which constitute the order Diptera. Only a very few species of this great family can in strictness be included as household pests, and first on the list may be placed the house-fly proper (*Musca domestica*), a photograph of which accompanies this article.* This is a medium-sized and inconspicuous insect, which, at first glance, seems to have no special adornment of any kind, but to be simply of a more or less uniform greyish black, with transparent wings slightly tinged with grey. But this first impression will be corrected by a closer scrutiny, which will discover many quiet beauties of one kind and another. Two of the chief items which determine the personal appearance of a fly belonging to this group are stiff, projecting hairs (or rather bristles), and what at first looks rather like a kind of rime, but on microscopic examination turns out to be crowds of exceedingly minute hair-like or scale-like bodies lying close to the skin. The latter are mainly instrumental in producing whatever colour forms patterns or markings upon the otherwise frequently dull bodies of the flies, while the varying size and number of the former exercise an important influence upon the general aspect of the insect, and make all the difference between a sharply defined, and an indistinct outline of the body.

The skin of the house-fly, on the upper surface, is in itself chiefly black, but the rimy covering (called collectively "tomentum"), which is scattered pretty thickly over it in most parts, gives it a greyish spotted appearance on the abdomen, causes also the resemblance of four dark lines of the thorax, where bare spaces are left, and beautifully adorns the face with a bright silvery covering. The large compound eyes are of a vinous red, and present a pretty contrast to the soberer colours of the rest of the insect. Underneath, the fly is quite pale, *i.e.* the ground colour of the skin itself is pale, as well as the tomentum. Its bristles are not sufficiently large or numerous to become a noteworthy feature in its aspect. It has no power of stinging or piercing, and, therefore, is not a bloodsucker, and simply worries us by the tickling sensation it produces when trying to sip the perspiration from our hands or face, or when simply running over the exposed parts of our bodies. It further annoys us by the dark spots of fluid excrement (fly-spots) with which it disfigures any object over which it runs. It is notably the fly of the sugar-basin, for sweets seem very attractive to it; but it is not addicted to the habit of laying eggs on cold meat. It is most abundant in the end of summer and towards autumn.

Very much like this insect, but rather smaller, is a fly which was formerly known as *Musca domestica minor*, the "smaller house-fly." It is now called *Homalomyia canicularis*, and may be distinguished from *M. domestica* by its paler and much more pointed body, which is of a conical shape, and especially by the arrrangement of its wing-nervures. To appreciate this distinction, the accompanying diagram (Fig. 1.) may be compared with the wings of the fly in the photograph. The chief difference will be seen towards the tip of the wing; if the third nervure on the disc of the wing in this part be compared in the two, it will be found to make an obtusely angular bend forward to the tip in *Musca*, but only to run forward to the margin without any angular bend in *Homalomyia*. This feature, taken in conjunction with the others here mentioned, will greatly aid the identification of this little fly. The male, which is by far the commoner sex, has at the base of the abdomen large pale patches which are semi-transparent; hence, when the fly is sporting about on the window panes, as it delights to do, the light shines completely through that part of the body, the pale patches looking like windows provided for the inspection of its internal anatomy. This little fly, especially the male, delights to hover and sport about in our rooms, and is exceedingly common. It has brilliant red eyes in exquisite silvery settings, like its larger relative, save that the colours are more intense.

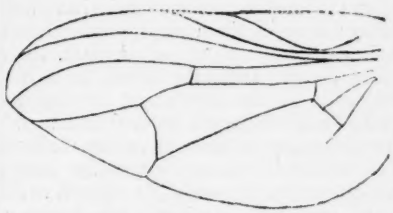


Fig. 1.—Wing of Homalomyia Canicularis.

Of a more robust type than this, with broader and shorter body than even the house-fly proper, is an insect which may be at once distinguished by the curious shape of its proboscis, which projects straight in front of its head, like a sharp-pointed needle. It is a far more troublesome creature than the other two, as a glance at its vicious-looking proboscis would immediately suggest. It is one of the so-called biting or stinging flies, and has earned an evil reputation by its persistent habit of piercing the skin for the purpose of sucking blood. It will, of course, not be confounded with the gnat or mosquito, which belong to a totally different family, and one to which we are not now alluding. This stinging fly is named, very descriptively, *Stomoxys calcitrans*, the "sharp-mouthed stinger." If seen by itself, it would probably be mistaken for a house-fly, unless the extraordinary nature of the proboscis were noticed; but when the two insects are placed side by side, many other differences become apparent, at least to the trained eye. *Stomoxys* is not only smaller than *M. domestica*, but it carries its wings

* The two plates illustrating this number of Knowledge have been made from photographic enlargements prepared by Messrs. Frederick Newton and Co., opticians, of No. 3, Fleet Street, who have kindly lent their original negatives for the purpose.

wider apart when not flying, and is more thickly covered with a greyish tomentum; its eyes, moreover, are not so red. But the strongest point of difference lies in the proboscis, and in the disagreeable habits of which that is the surest indication. These three flies constitute the majority of what in houses are commonly regarded as house-flies, or are simply called flies.

But besides these, there is the far larger Bluebottle, Blow-fly, or Meat-fly; this is usually one or other of two closely allied species, *Calliphora vomitoria* and *C. erythrocephala*. A bluebottle is easily recognisable by its much larger size, its proportionately broader body, of a shiny blue or violet colour, and the loud buzzing with which it heralds its approach. Like its companions, it is red-eyed, but its face is not silvery, only a narrow margin of silver being visible behind each eye, while all the lower parts of the face are more or less of a pale reddish yellow; it is also more hairy than the other species. When in good condition, it may be seen to possess a tomentum like the others, and this, in certain lights, imparts a curious appearance to the steely blue of its skin, reminding one of the lustre of shot silk. These flies are, in the house, the chief assailants of cold meat, of which they not merely suck the juices, but on which they deposit great numbers of eggs, known as "fly-blows," whence will issue maggots, whose one business will be to demolish the solid parts. Thus each of the above species, all of which are exceedingly common household pests, is distinguished not merely by a characteristic form, but also by habits peculiar to itself.

Besides these, several other species also sometimes invade our houses, and it must be remembered that in all cases it is an *invasion*; none of them are home-bred, but all have spent their early life and passed through their metamorphoses out of doors. It would indeed be a disgrace to our civilisation if the interiors of our houses afforded any suitable breeding-ground for such creatures; they are all nurtured amidst putrid and refuse matters, and the mere sight of their hideous, worm-like larvæ, commonly known as maggots, or gentles, is enough to fill one with disgust and loathing. Most valuable, however, are their labours in this stage of their life; they are the great scavengers of the earth, and contribute in no slight degree to the purity of its atmosphere. Of the other *Muscidæ* that, in their adult condition, more or less frequently occur indoors, we need not stay to speak now, but will reserve a few remarks about them till the end of the present series; the above five species will be the only ones we are concerned with at present, as they will probably be the sole representatives of the family met with in towns. In the country, of course, many others will be added to the list, since an open window in such situations proves to not a few of the other restless two-winged insect inhabitants of fields, hedges, and ditches, a temptation too strong to be resisted. But even in such cases, the above species will greatly preponderate. Some years ago, the writer was staying, in the month of August, at a country house which was suffering from an exceptionally severe plague of flies; they swarmed in every window, of which there were not a few, and made an intolerable buzzing; as they died their carcases accumulated on the window-sills. On examining the heaps of bodies, a considerable variety of species was discovered, and several were noticed whose presence was quite unexpected; still, out of many scores of specimens examined, by far the largest proportion consisted of the one species—*Stomoxys calcitrans*.

Before discussing in detail the structure and life history of these different flies, a few words seem to be necessary in explanation of the photographs which accompany this article. The fly represented is the common house-fly (*Musca domestica*), and the photograph, having been prepared from a specimen mounted as a transparent object for the microscope, necessarily shows the insect in a somewhat distorted condition, consequent on the flattening requisite to render it of any use as a micro-slide. It has further been arranged in such a position as to exhibit as much as possible of fly-structure at one view. Hence the head appears deeper than it otherwise would, having been bent back from its natural position so as to bring into view its hinder surface, and so to throw the mouth organs forward, thus enabling the wonderfully complex organ commonly called "proboscis," or "tongue," to be fully stretched out and exhibited in its entire length. In life the head would, of course, be set on in a vertical position, and hence its depth from back to front would not be so great, and the "tongue" would be more or less folded up and bent underneath the head, and would never project as shown in the photograph. At the opposite end of the body, also, is seen an organ that would, in life, be ordinarily concealed, viz. the so-called "ovipositor"; this is quite a different thing from the organ similarly named in an ichneumon fly, or the sting of a bee, and merely consists of the last three segments of the body, which, being much narrower than the rest, can be retracted within the body, closing up like the tubes of a telescope. By this arrangement the eggs can be conveyed into narrow crevices and cavities too small to admit of the entrance of the entire insect. The flattening of the convex abdomen, also, has abnormally opened out the segments at their edges, so as to expose the thin transparent parts of the skin which intervene between the thicker and more chitinous rings, and are usually concealed by the overlapping of the segments. The two front pairs of legs, having been pressed down into one plane, appear abnormally long, and give the insect the appearance of being able to cover a larger area than it ever would do in life; finally, the wings have been purposely placed in a position intermediate between that which they would assume when at rest, and when in use. The plate represents the under side of the fly.

The other plate shows part of the "tongue" of the blow-fly, details of which must be reserved for the next paper. Reference to the whole insect will show that only a little more than two-thirds of the organ are here present; this is all that is usually mounted, the basal part having been cut off because it does not so readily flatten as the rest. The two lobes which form a heart-shaped mass at the outer (distal) extremity, are not naturally carried in that position, but folded upon one another in a vertical plane, with the outer edges pointing downwards, and they are opened out on being applied to any object for feeding purposes. The two prominent club-shaped organs at the base are the single-jointed maxillary palpi, and when the proboscis is retracted, it is bent upon itself at a point just beyond their insertion, so that the palpi lie along the central division of the apparatus, and their tips reach to the sides of the mouth, which is seen just in front of the dark central mass, at the hinder end of the cleft between the two labial lobes. Of course, only the chitinous portions of the organ are present in the preparation; and for this reason, as well as in consequence of the flattening for microscopic purposes, it is difficult to understand the action of this "tongue" unless the preparation be compared with the organ in its natural condition. It is, moreover, not very easy to learn the *modus operandi* by observation of the living fly, both on account of the vivacity of the insect, and the copiousness of the flow of saliva, which has a tendency to accumulate so as to obscure the view of the minuter details.

## WHERE WAS THE ARYAN CRADLE FIRST ROCKED?*

By Edward Clodd.

SIR WILLIAM JONES'S study of Sanskrit, and his inference as to its close relation to the leading European languages, was followed by the researches of Fr. von Schlegel and Bopp, published in 1808 and 1833 respectively, the results of which were to confirm and extend the conclusions of our own countryman. From these there was deduced the seemingly logical inference that the races speaking these languages were connected by blood, and that they were the scattered descendants of an ancestry whose primitive home was in Asia.

All this fitted in so well with ancient traditions and records, both "sacred and profane," of the birthplace of man and the rise of civilisation in the East, that the theory of the origin of the Aryan-speaking peoples in some part of Central Asia found well-nigh universal acceptance, only a voice or two here and there being heard "crying in the desert" of opposition. Most of us can remember the wondrous charm with which Professor Max Müller, in whom is combined qualities so rare among Germans, namely, the power of presenting facts in attractive guise, invested the subject; with what skill he used the materials furnished by language to construct his brilliant sketch of old Aryan life in Bactria. Learned and unlearned alike embraced the elaborated theory, and felt no doubt that the last word had been said on the subject. "At the breast of our Asiatic mother, the Aryan people of Europe have rested; around her as their mother they have played as children. There or nowhere is the playground." And all the people said, Amen.

But now well-nigh every scholar, be he philologist or ethnologist, has performed the *volte-face*. Not Professor Max Müller with them; he still stands firm as tower "built four-square to all the winds that blow." Amongst them, however, is his *fidus Achates* and deputy, Professor Sayce, of whom he may pathetically say, "It was not an enemy, else I could have borne it."

The old theory, for such we must now term it, was in parlous state from the moment that disproof fell upon its main assumption, that identity of language implies identity of race. Skulls are harder than consonants, and while the "hall-mark" of a race is never wholly rubbed out, its language is as unstable as the sea-waves. Not only do an infinity of causes from within operate to bring about change; causes from without, through conquering races or through intermixture with races of superior culture, effect momentous alterations, often sweeping away the old language and imposing a new language upon the subdued or intellectually inferior race. "The language of Cornwall is the same as the language of Essex, but the blood is Celtic in the one case and Teutonic in the other. The language of Cornwall is different from that of Brittany, but the blood is largely the same. Two related languages, such as French and Italian, point to an earlier language from which both have descended; but it by no means follows that French and Italians, who speak those languages, have descended from common ancestors." † "Language," as Professor Sayce has remarked, "is a test of social contact, not of race," of which illustrations are supplied by the adoption by the Jews of the language of the several countries in which they have settled, and by the use of English, more or less corrupted, among the diverse races, European, Negro, and Red Indian, of the United States.

But not only is the theory of a parent Aryan race living in a somewhat advanced state of culture in Asia, and sending forth successive swarms westward, discredited; the existence of an Aryan race at all, as commonly understood, is called in question. "It is now contended," Canon Taylor says, "that there is no such thing as an Aryan race in the same sense that there is an Aryan language, and the question of late so frequently discussed as to the origin of the Aryans can only mean, if it means anything, a discussion of the ethnic affinities of those numerous races which have acquired Aryan speech; with the further question, which is perhaps insoluble—among which of these races did Aryan speech arise, and where was the cradle of that race?" (p. 7). The learned Canon, whose knowledge is of the encyclopædic type, has placed us under no slight obligation in summarising, with the addition of valuable suggestions from his own agile mind, the labours of the chief continental scholars to whom the revision of the old theory is due, and whose conclusions, although differing as to the precise site, agree in pointing to Europe as the original home of the races speaking the languages grouped under the inexact but accepted term Aryan. Although the new school lays lighter stress on the evidence of language, on which the old school in the main based its conclusions, the adversaries have been met on that ground and compelled to beat retreat. The old school rested its case on the existence of more archaic forms of Aryan speech in Sanskrit and Zend, arguing therefrom that these lie nearest the source. But this evidence is drawn from comparison of documents—the Rig-Veda and the Avesta, the Indian and Iranian scriptures respectively—and against this there is set the yet older evidence supplied by unwritten materials, as, *e.g.*, the Icelandic language, and, still more, the Lithuanian, which among European languages has the best claim to represent the primitive Aryan speech, and "has not extended itself, those who now speak it being probably the direct descendants of those who spoke it two, or possibly three thousand years ago." ‡

It is fair to surmise that if we possessed a Lithuanian literature of a date contemporary with the oldest literature of India (which is older by nearly three thousand years than the Lithuanic), it might be contended, with greater reason, that the cradle of the Aryan languages must have been in the Lithuanian region. "In like manner it is not fair to compare ancient Zend with modern German. But if a comparison is made between modern Persian and the vernacular Icelandic, the latter is seen to have preserved the more archaic forms, so that if the argument from archaism be admissible, and the argument is confined to these contemporary languages, it would be more reasonable to place the Aryan cradle in Iceland than in Britain." § As against this it is, however, well to cite Professor Keane's caution, that we may admit, "with Schrader, that some of the phonetic and structural elements of the primitive Aryan speech have been better preserved in the west than in the east, without accepting the inference that therefore these elements were necessarily first developed in the west. Some old English forms, for instance, have been better preserved in Ireland and North America than in Great Britain, and even than in their original home in North Germany." ‖

* *The Origin of the Aryans: an Account of the Prehistoric Ethnology and Civilisation of Europe.* By Isaac Taylor, M.A., Litt.D., Hon. LL.D. (London: Walter Scott.)

† Taylor, p. 5.

‡ Taylor, p. 258.

§ Taylor, p. 16.

‖ Appendix to Stanford's *Europe*, p. 557.

But apart from this, the evidence supplied by comparison of vocabularies, is clearly in favour of the European theory. There is important testimony afforded by the beech, over which Professor Sayce was birched for his confusion of the two trees, and the arguments respecting which have been shortly stated in a paper by Canon Taylor, read at the British Association Meeting last year, and published in this journal.* The beech does not grow east of a line drawn from Konigsberg through Poland and Podolia to the Crimea, and while the name for it is common to the Celts, Teutons, Greeks, and Latins, it is a loan-word from these amongst the Slaves, but is absent from the Indian and Iranian languages. Then, whilst there are common words for winter—the one defined and dominant season—and for spring and summer, there is no word for autumn, from the absence of which we may infer that the primitive Aryans had not advanced from the nomad stage to the agricultural stage. Oddly enough, there is no common word for river, but a uniform word for the sea, or for some large body of water, in the European group, Greek excepted. There is no common word for the lion, or the tiger, or the ass, the native homes of which (not speaking of the cave-lion, cave-tiger, &c., found in the Palæolithic deposits) are in Asia, while the name of the camel is a Semitic loan-word. There is no common name for fish, and while that for oyster is the same in all the European Aryan languages, it is wanting in the Asiatic Aryan languages. "If," Canon Taylor remarks, "the Aryans originated in Europe, the loss of the word in lands where the oyster is unknown is perfectly intelligible." (p. 170.)

Such are a few examples from the great body of words evidencing that the primitive Aryans were a pastoral people, spread over lands where the climate was cold, and in the vicinity of large bodies of water. But languages undergo more or less rapid or violent change, and words get worn away, dropped-out, or mixed up, and otherwise altered. And therefore the evidence on which the theory of European origin is based is drawn from less fluctuating materials, from the new sciences of Palæontology and Archæology, grouping these under Anthropology—the Science of Man. The following of tracks of his undoubted presence, the examination and comparison of human skulls and skeletons and "works of dead men's hands," preserved in caves and tombs and tumuli and temples, have been the chief modifying causes of this curious reversal of a verdict of which the deliverance seemed clear and final.

How all this has been done, and with what marked agreement in the main, is set forth, skilfully cited and sifted, by Canon Taylor, first in general summary, and then more in detail. The book, as already hinted, is itself chiefly an abstract of larger works, notably of that by Dr. Schrader, and it is therefore not possible to give even an approach to an outline of the subject. But in seeking for the strong points in favour of the new theory, we find, firstly, nothing more cogent than that raised by Dr. Latham, as far back as 1854, and given due place of honour by Canon Taylor; and, secondly, Dr. Thurnam's suggestion that the Primitive Aryans are represented in Britain by the broad-headed men found buried in the round barrows of the Newer Stone Age. The continuity of race in Europe from the earliest Neolithic times (we are not inclined, in view of the vast lapses of time between the two periods and the climatal and other physical changes, to accept the theory of continuity from Palæolithic times) being proven, where is the evidence for the sudden and periodic immigrations of Asiatics from warmer regions over frozen steppes, or by southern shores, who swamped or, according to the wild talk of defunct historians, annihilated the non-Aryan Europeans? We find the main body of the Aryan-speaking peoples in Europe, and but a small detached body in Asia—the main trunk here, two severed branches there. Which is the more probable: that the smaller body broke away from the larger, or the larger body from the smaller? The mass of Mongolians dwell in Eastern Asia, and for this very reason Asia is accepted as the original home of the Mongolian race. The great mass of Aryans (*i.e.* of Aryan-speaking peoples) live in Europe, and have lived there as far back as history sheds a ray of light. Why, then, not apply to the Aryans and to Europe the same conclusions as hold good in the case of the Mongolians and Asia? And why not apply to ethnology the same principles as are admitted unchallenged in regard to the geography of plants and animals? Do we not in botany and zoology seek the original home and centre of a species where it shows the greatest vitality, the greatest power of multiplying and producing varieties?† Canon Taylor has represented Dr. Latham's argument by a diagram.

"The European Aryans form a closely united circular chain of six links; but there is one vacant place—one link is missing from the chain. This missing link is discovered far away in Asia, where we find the Indo-Iranians, who are very closely united with each other, but whose affinities with the European Aryans are chiefly with the Slaves on the one hand and with the Greeks on the other. They clearly constitute the missing link in the chain, which would be complete in its continuity if they had at some former period occupied the vacant place." (p. 22.)

Space forbids more than brief reference to the distinguishing feature of this book, namely, the thoroughness with which Canon Taylor has worked out Dr. Thurnam's suggestion as to the identity of the "Celts" of the round barrows with the great broad-headed races of Central and North-Eastern Europe and Asia. Numerous illustrations in the work show what differences of skull and profile mark off the long-headed from the broad-headed people, and what means of identification these least variable features of race afford. Without doubt they establish the theory of connection between widely-spread types of men of different speech.

Although it seems no longer matter of doubt, after review of the evidence, that the cradle of the Aryans was westward rather than eastward, somewhere on the wide plateau stretching from the shores of the German Ocean, we may gravely question whether the exact habitat can be more than approximately known.

Poesche is surely to be charged with unconscious humour in placing the origin of the Aryan race in the marshy land of the great Rokitno swamp, although he gives us sober reason for his theory that in that district Albinoism is prevalent, and that thence, consequently, a fair-skinned race may have arisen, especially as the white Russians now dwelling there become rapidly vigorous when removed to more favourable surroundings. Penka argues for Scandinavia; Cuno for the great plain of Northern Europe, from which migrations to Scandinavia may have taken place; while Schrader, without attempting to fix the precise region, is satisfied that it must be sought north of the Alps. On the whole, Canon Taylor, as he remarks in his preface, finds himself in agreement with

* See Knowledge, November 1889.

† *Cf.* Rydberg's *Teut. Mythol*, p. 11.

Cuno, while striking out a somewhat different path. He says: "We have come to the conclusion that the Celto-Slavic race best represents the primitive Aryans, whose speech may have been evolved out of a language of Ural-Altaic class. We may, therefore, conjecture that at the close of the Reindeer age a Finnic people appeared in Western Europe, whose speech, remaining stationary, is represented by the agglutinative Basque, and that much later, at the beginning of the pastoral age, when the ox had been tamed, a taller and more powerful Finno-Ugric people developed in Central Europe the inflective Aryan speech. By this hypothesis many difficulties would be reconciled." (p. 296.)

By the "Reindeer age" is understood a later stage of the Palæolithic age, when that animal formed the staple food of the Cave-men, whose relics, as in their rude pictures on stag-horns and mammoth tusks, evidence advance upon the men of the Drift period. The appearance of the reindeer coincides with that of the woolly-haired elephant, and other denizens of a cold region, and no bones of these animals occur in the Neolithic deposits of Western Europe. So far, therefore, as Canon Taylor's remarks imply continuity of succession between Reindeer man and Finnic man, they appear to require modification. Concerning the origin of the "inflective Aryan speech," the Canon amplifies his previously published theory, based upon "deep-seated structural agreements between the Aryan and Finnic languages too profound to be explained by geographical contiguity, commercial intercourse, inroads, wars, or political supremacy," that the Finnic languages "exhibit a survival of the primitive form of speech out of which the Aryan languages were developed; the archaic semi-agglutinative Lithuanian approaching most closely to the Finnic, which is semi-inflectional" (p. 295). In the agglutinative stage of language the elements out of which words are formed unite with, or are, so to speak, "glued" to the root, neither obscuring nor changing it. In the inflectional stage, the formative and radical elements are changed and amalgamated. But there is no sharp line of division between the two, one stage passing gradually into the other whenever changes set in. Canon Taylor's theory has not, however, found support from many philologists. Among them Professor Terrien de Lacouperie fails to recognise "the primitiveness of the dubious identities pointed out," and says that "all that is Aryan in the Finnic languages is borrowed, and does not belong to the ground-speech of the family, as shown beyond controversy by Algrist, Budenz, and Donner."* He "conjectures that an intermingling of tribes—allophylian whites and Semitic—may have produced the primitive Aryan ethno-linguistic nucleus. From all which we learn how much yet remains, perchance will always remain, unsettled, to the advantage of quickening the spirit of research, of which this volume is one of the most interesting recent results.

## VARIABLE STARS.

By A. C. Ranyard and C. E. Peek.

To the casual observer there is nothing which appears so unchanging as the fixed stars, but, when closely observed, changes of several kinds are found to be going forward. Most stars are slowly shifting their places, and many vary in both colour and brightness. While the changes of place are so slow that if Job were to return he would notice no sensible change in the familiar groups, the changes of brightness are in some cases so considerable, and so rapid, that a few days or even hours occasionally make a very noticeable difference. Variable stars may be divided into three great groups:—1. Variables of the Algol type; 2. Temporary stars or novæ; and 3. Variables with more or less regular periods.

1. Variables of the Algol type remain at their maximum brightness for the greater part of their period, and then decrease in brilliancy for a few hours, returning again to their former maximum brightness. Most stars of this class go through their round of changes in a few days. Thus Algol remains constant at about the 2·2 magnitude for the greater part of its period of 69 hours, but during about four and a half hours its light decreases till it reaches a minimum of about the 3·7 magnitude, and, after remaining at its minimum brightness for a short time, it increases till it again reaches the 2·2 magnitude. The whole series of changes occupy about ten hours. Prof. E. C. Pickering has very carefully studied the changes in brightness of Algol, and has shown that the diminution of light is probably due to the eclipse of the bright star by a dark companion or swarm of meteorites, and Prof. Chandler of Boston has shown that the period occupied by the cycle of changes is slowly diminishing. When the variability of Algol was discovered by Goodricke in 1782, its period was 2d. 20h. 48m. 59·5s., whereas it is now only 2d. 20h. 48m. 51s. There are several variables of this type with somewhat longer, and others with still shorter, periods; for example, *S. Cancri* has a period of 9d. 11h. 37¾m., while *R. Canis Majoris* completes the cycle of changes in 27 hours.

2. Temporary stars or *novæ* are those which blaze out suddenly in the course of a few days, and then slowly decrease in brightness till they are lost to view. Some of them have exceeded the planets in brightness, and have been seen in the daytime; thus Tycho Brahé's new star in *Cassiopeia*, when first seen by him on the 11th of November 1572, was more brilliant than Jupiter, then in opposition, and almost rivalled Venus in brightness. It continued to shine with undiminished light during the month of November, and then began sensibly to decline till it ceased to be visible in March 1574, nearly a year and a half after its first appearance. Kepler's great "New Star" in the constellation of *Serpentarius* seems also to have blazed out suddenly. It was first seen on the 17th of October 1604, and was then a brilliant white, exceeding Mars, Jupiter, and even Venus in splendour. Like the star of 1572, it began to decline soon after its appearance, and, finally, ceased to be visible after about a year—that is, between October 1605 and February 1606. There is now a star of about the 12th magnitude near the position deduced by Schönfeld from the observations of Fabritius of this variable; but its identity with the great *nova* cannot be considered as proved. In more modern times several smaller stars have suddenly come into view, and some of them have died down, leaving a small star in their place. Thus Hind discovered a new star in April 1848 between 7 and 20 *Ophiuchi*. It increased from the 5th to the 4th magnitude, and then rather rapidly faded to the 10th magnitude. It was of the 12th magnitude in 1862, and not above the 13th in 1875. A star which appeared near 75 *Cygni* in November 1876 and attained the 3rd magnitude, has now died down to the 15th magnitude. It was this star which Lord Crawford described as having changed into a planetary nebula, for its spectrum showed bright lines like those of T *Coronæ* when it was at its brightest; and as the star faded the spectrum changed, becoming discontinuous like that of a nebula. More recently (in August 1885) a bright star of the 7th magnitude appeared near the nucleus of the

* *Academy* May 5, 1888.

great nebula in Andromeda.* It has since slowly died down, and is now quite lost to view.

At first sight it is difficult to conceive how bodies so large and so brilliant as such stars must be can cool down and lose their light in a few months; but a suggestion has

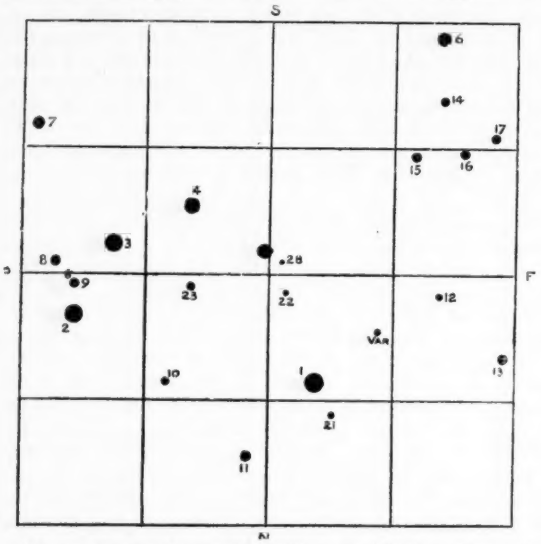



Fig. 1.—Stars about S. Ursæ Majoris which have been used for determining its magnitude.

been made by Mr. Monck which seems to get over the difficulty. He supposes that only the outer envelope of the star is rendered incandescent on its plunging into a nebulous area, or a region rich in meteoric *débris*. The star would thus only be superficially heated, but intense light would be emitted much in the same way as by a swarm of meteors rushing into our air. On emerging from the nebulous region, the star would rapidly cool. It is worthy of remark that there is no evidence to show that any of these temporary stars increase in brightness at regular intervals.

Mr. Peek has devoted himself to the study of the remaining and largest class of variables, which increase and decrease in brightness at more or less regular intervals. He has selected for special observation twenty-five variable stars, with periods ranging from 220 to 615 days. These have been compared on every available night, either by himself or by his assistant, Mr. Grover, during the last three and a half years, with the brightness of stars in their immediate neighbourhood. The method is to estimate the brightness of the variable to the nearest tenth of a magnitude as compared with five or six adjacent stars, and to take the mean of the magnitudes determined from the comparisons. The map, Fig. 1, shows the stars, within a square degree of the heavens, which have been used for comparison with *S. Ursæ Majoris*, a variable which, according to Mr. Gore, has a reputed period of 224·8 days. The first step is to make sure that none of the comparison stars are variable, by repeated comparisons of one with the other. The next is to assign magnitudes to the comparison stars. If there are any errors in the magnitudes assumed for the comparison stars it will not greatly affect the value of the observations, for it will only shift the scale of magnitudes in a manner which can at any time be rectified when the true magnitudes of the comparison stars are better determined. The accompanying curve, Fig. 2, shows the changes which have taken place in the brightness of *S. Ursæ Majoris* since July 1886. It will be noticed that the star does not always rise to the same brightness at its maxima, and the differences of brightness at different minima are still more striking. The remarkable irregularities of the curve cannot be accounted for as merely due to errors of observation, for the probable error of a single comparison with a neighbouring star does not exceed two tenths of a magnitude, and some of the irregularities in the curve correspond to changes of half a magnitude. The assumed magnitudes of the comparison stars are no doubt considerably in error, especially in the case of the smaller stars, that are not far from the limit of visibility, which in the telescope of $6\frac{4}{10}$ in. aperture used about corresponds to the thirteenth magnitude, but a correction of such errors would only compress or elongate the lower parts of the curve corresponding to the minima of the variable.†

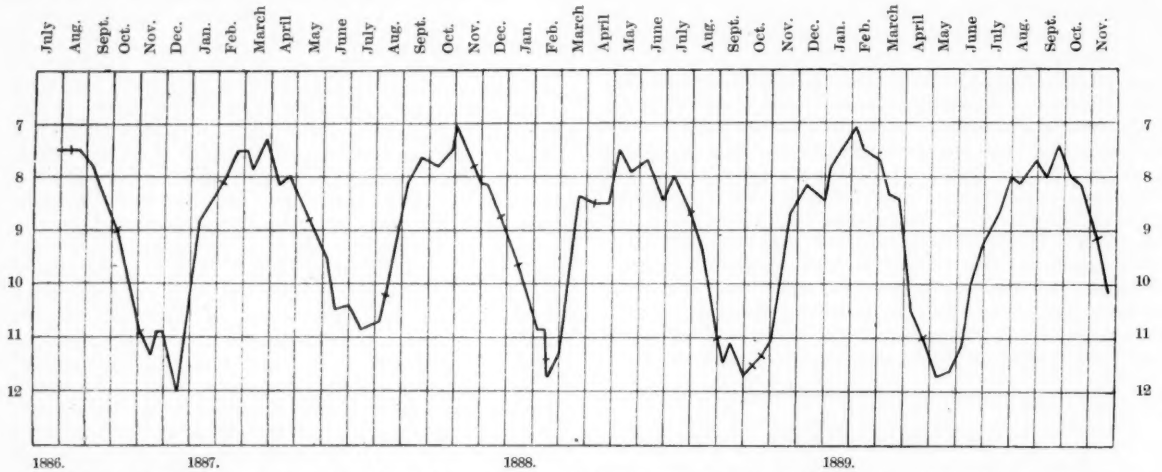

July Aug. Sept. Oct. Nov. Dec. Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. March April May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. March April May June July Aug. Sept. Oct. Nov.
7
8
9
10
11
12
1886.
1887.
1888.
1889.

Fig. 2.—Diagram showing variations in brightness of S. Ursæ Majoris from July 1886 to Nov. 1889. as observed at Rousdon.

* See Knowledge, Feb. 1889, p. 76.

† The magnitudes of the comparison stars have been re-checked from time to time. The following table shows the magnitudes deter-

Fig. 3 has been made from a series of observations of the magnitude of *S. Ursæ Majoris*, which have been kindly sent by Prof. Pickering. The brightness of twelve of the comparison stars used at Harvard have been determined with Prof. Pickering's Meridian Photometer, and they may consequently be relied on as being correct within two-tenths of a magnitude. It will be noticed that the Harvard observations carry the minimum down to a point which approaches the limiting magnitude of stars just visible with Mr. Peek's telescope, and the discrepancy is greatest where the Rousdon errors are likely to be largest; otherwise the Harvard observations tend to confirm those made at Rousdon, and they show similar irregularities in the increase and decrease of brightness.

Similar irregularities are found in the curves representing the brightness of the other variable stars which Mr. Peek is observing; but each curve has its own character, some being more irregular than others.

It will be noted that the rise of the curve is rather more rapid than the descent, a characteristic which reminds us of the sun-spot curve. This appears to be a general law of these variables, and is borne out by an examination of the atlas of curves, which represent the Rousdon observations. There is also a decided difference in the distance

mined for the first fifteen stars on the chart. Star No. 18 has been assumed to be the 10·5 mag., No. 22 the 11·0 mag., No. 23 the 10·0 mag., and star No. 28 the 11·6 mag.

| Star. | July 26. 1886. | Aug. 11. 1886. | Aug. 27. 1886. | Sept. 10. 1887. | Sept. 16. 1888. | Mean. |
|---|---|---|---|---|---|---|
| 1. | 6·0 | 6·0 | 6·5 | 6·0 | 6·0 | 6·1 |
| 2. | 6·5 | 7·3 | 7·0 | 7·0 | 7·3 | 7·0 |
| 3. | 6·5 | 7·0 | 7·2 | 6·8 | 7·0 | 6·9 |
| 4. | 8·0 | 8·0 | 8·5 | 8·0 | 7·8 | 8·1 |
| 5. | 8·0 | 8·0 | 8·5 | 8·8 | 8·5 | 8·4 |
| 6. | 8·6 | 8·5 | 8·8 | 8·3 | 9·0 | 8·6 |
| 10. | 10·0 | 9·6 | 9·9 | 10 5 | 10·0 | 10·0 |
| 11. | 9·8 | 9·6 | 9·7 | 10·0 | 9·8 | 9·8 |
| 12. | 10·0 | 10·0 | 10·0 | 10·5 | 11·0 | 10·3 |
| 13. | 9·7 | 9·6 | 9·7 | 9·8 | 10·0 | 9·8 |
| 14. | 9·8 | 9·5 | 10·0 | 19·5 | 10·0 | 10·0 |
| 15. | 9·5 | 9·4 | 9·7 | 10·4 | 9·4 | 9·7 |

## VARIABLE STAR OBSERVATIONS.

R.A. $12^h\ 39^m\ 8^s$. S. URSÆ MAJORIS. DEC. $+61°\ 41{\cdot}7'$.

| Date. | Mag. | Compared with. | Remarks. |
|---|---|---|---|
| 1886. | | | |
| July 26 | 7·5 | 2, 3, 4, 5 | Light reddish star. |
| Aug. 11 | 7·5 | | Slightly ruddy. |
| ,, 22 | 7·5 | | Reddish. |
| Nov. 23 | 10·9 | | Sharply defined ruddy star. |
| Dec. 15 | 12·0 | 12 | Very minute, but well defined. |
| 1887. | | | |
| Jan. 12 | 8·8 | 5, 12 | Distinctly ruddy star. |
| Feb. 5 | 8·1 | 5, 4, 3, 2 | Distinctly ruddy star. |
| ,, 21 | 7·5 | 5, 4, 3, 2 | Slightly red star. |
| Mar. 11 | 7·9 | 3, 4 | The ruddy tinge is very pale. |
| ,, 27 | 7·3 | 1, 2, 3, 4, 5 | Reddish star. |
| Apr. 11 | 8·1 | 4, 1, 3 | Bright reddish star. |
| ,, 25 | 8·0 | 4, 5 | Light red. |
| May 16 | 8·8 | 4, 5 | ,, |
| June 8 | 9·5 | 12, 8, 9, 13, 6 | Reddish star. |
| ,, 16 | 10·5 | 12, 13, 14, 15, 16, 17 | Ruddy star. |
| Sep. 10 | 8·1 | 4, 5, 2, 3, 1 | Bright reddish star. |
| ,, 22 | 7·6 | 4, 3, 2, 5, 1 | ,, ,, ,, |
| Oct. 13 | 7·8 | 2, 3, 4, 5, 1 | ,, ,, ,, |
| ,, 23 | 7·5 | 2, 3, 4, 5, 1 | A decidedly red star. |
| Nov. 1 | 7·1 | 2, 3, 4, 5, 6 | A decidedly light red star. |
| ,, 20 | 7·8 | 4, 5, 6, 3, 2 | Decidedly ruddy. |
| ,, 29 | 8·1 | 4, 5, 3, 2, 6 | A light reddish star. |
| Dec. 7 | 8·2 | 4, 6, 5, 7 | ,, ,, ,, |
| ,, 22 | 8·7 | 5, 4, 12, 11, 10 | A decidedly red star. |
| 1888. | | | |
| Jan. 14 | 9·6 | 12, 13, 15, 16 | Decidedly red. |
| Feb. 4 | 10·8 | 12 | (Clouds suddenly came on). |
| ,, 12 | 10·8 | 12, 13, 10, 11 | ("a" night). |
| ,, 14 | 11·4 | 12, 14, 10, 11 | ("a" night). |
| ,, 15 | 11·7 | 12 | ("a" night), small but distinct with 80. Ruddy tinge perceptible. |
| ,, 17 | 11·7 | 12 | Barely seen 25, very small 80, distinct 90. |
| ,, 29 | 11·3 | 12, 13 | Minute but sharply defined 80 and 90. Not seen 25. |
| Mar. 21 | 8·3 | 3, 4, 1, 7 | Distinct red star with 25. |
| Apr. 10 | 8·5 | 5, 3, 2, 6 | Very light red. |
| ,, 26 | 8·5 | 2, 3, 5, 1 | A light red star. |
| May 12 | 7·5 | 2, 5, 6, 11, 3 | A decidedly red star. |
| ,, 23 | 7·9 | 3, 2, 5, 4, 1 | ,, ,, ,, |
| June 9 | 7·7 | 2, 3, 5, 6, 1 | Light red star. |
| 1888. | | | |
| June 27 | 8·4 | 1, 2, 3, 5, 6 | A decidedly red star ("b" night). |
| July 11 | 8·0 | 2, 3, 5, 6, 7 | A light red star ("a" night). |
| ,, 28 | 8·7 | 5, 7, 6, 8, 9 | Reddish ("c" night). |
| Aug. 14 | 9·4 | 10, 11, 12, 13, 15 | Du'l red or ruddy ("a" night). |
| ,, 30 | 11·0 | 10, 11, 13, 12, 15 | Very sharply defined, ruddy ("a" night). |
| Sep. 6 | 11·4 | 10, 11, 12, 13 | Red colour distinct with power 34 ("a" night). |
| ,, 14 | 11·1 | 10, 12, 13, 11 | Minute but sharp with 34 ("a" night). |
| ,, 30 | 11·7 | 12, 10, 11 | Very minute but sharply defined ("a" night). |
| Oct. 9 | 11·5 | 9, 10, 8, 11, 12 | Minute and sharp with 34 ("a" night). |
| ,, 21 | 11·3 | 10, 12, 11, 13 | Very small 34 (moon rising). |
| ,, 30 | 11·1 | 10, 11, 14, 12, 13 | Deep dull ruddy. Distinct 34 ("a" night). |
| Nov. 22 | 8·7 | 5, 6, 4, 14, 15, 16 | Very red, sharply defined ("a" night). |
| Dec. 9 | 8·2 | 2, 3, 5, 6, 7 | Deep red, not very well defined ("a" night). |
| ,, 29 | 8·4 | 2, 3, 4, 5, 15 | Deep dull ruddy ("a" night). |
| 1889. | | | |
| Jan. 7 | 7·8 | 2, 3, 4, 5, 6 | Decidedly red ("a" night). |
| Feb. 4 | 7·1 | 1, 2, 3, 4, 5, 6 | Decidedly red ("a" night). |
| ,, 15 | 7·5 | 1, 2, 3, 4, 5 | Deep ruddy ("a" night). |
| Mar. 1 | 7·7 | 2, 3, 4, 5, 6 | Pale red ("a" night). |
| ,, 13 | 8·3 | 2, 3, 4, 5 | Decidedly red and sharp ("a" night). |
| ,, 22 | 8·4 | 4, 5, 6, 15, 14, 16 | Deep ruddy. Hazy and ill-defined ("a" night). |
| Apr. 10 | 10·5 | 10, 11, 12, 13, 15, 16 | Decidedly red, sharp. |
| ,, 21 | 11·0 | 10, 11, 12, 13 | Very red ("a" night). |
| May 10 | 11·7 | 10, 11, 12, 13, 8 | Very minute 34. Sharply defined 80. (Moon 4 days old.) |
| ,, 22 | 11·6 | 12, 13, 22, 23, 28 | Distinct 34 ("a" night). |
| June 5 | 11·1 | 10, 11, 12, 13 | Easily seen 34. (Moon 7 days old.) |
| ,, 16 | 10·0 | 10, 11, 12, 13, 14 | Decidedly red, well defined ("a" night). |
| ,, 29 | 9·2 | 5, 6, 11, 12, 13 | Decidedly red and sharp ("a" night). |
| July 17 | 8·7 | 2, 3, 5, 6, 12 | Reddish, well defined ("a" night). |
| ,, 29 | 8·0 | 2, 5, 6, 15, 13 | Pale red, well defined ("a" night). |
| Aug. 11 | 8·1 | 1, 2, 3, 5, 6 | Deep dull red. (Bright moonlight.) |
| ,, 28 | 7·7 | 1, 2, 3, 5, 6 | Decidedly red ("a" night). |
| Sep. 12 | 8·0 | 1, 2, 3, 5, 6 | Very light red. Sharp ("a" night). |
| ,, 22 | 7·4 | 1, 2, 3, 5, 6 | Very red ("a" night). |
| Oct. 7 | 8·0 | 1, 2, 3, 5, 6 | A dull orange star. (Full moon). |
| ,, 19 | 8·2 | 2, 3, 5, 6 | Decidedly red. (Passing clouds.) |
| Nov. 6 | 9·1 | 5, 6, 11, 15, 16 | Very red, ill-defined. (Bright moonlight.) |
| ,, 25 | 10·2 | 10, 21, 11, 12, 13 | Deep red, dull, hazy ("a" night). |
| Dec. 11 | 10·8 | 10, 13, 11, 12, 21 | Small but sharp with 34 ("a" night). |
| ,, 22 | 10·9 | 10, 13, 11, 12, 21 | Small but sharp with 34 ("a" night). |

XUM

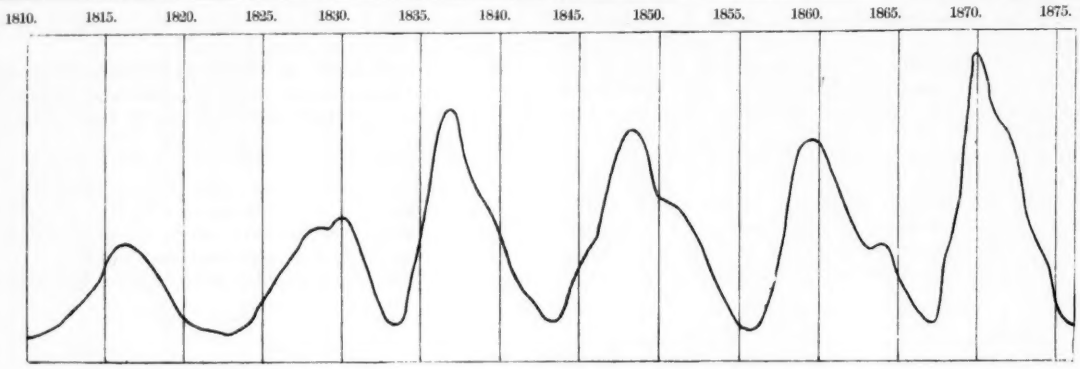



Fig. 4.—Curve showing the relative number of Solar Spots from 1810 to 1875, copied from Dr. Rudolf Wolf's paper in the Mem. R.A.S., Vol. XLII.

between successive maxima and successive minima, which is very marked in the sun-spot curve; so that we can no more predict with certainty the date of a maximum and the brightness of a star at its maximum, from former observations, than we can predict the absolute date of a sun-spot maximum or minimum or the number of spots that will be visible. Thus while the maxima and minima of the First, or *Algol*, class of variables can be predicted to a second of time, those of the third class can only be approximately predicted.

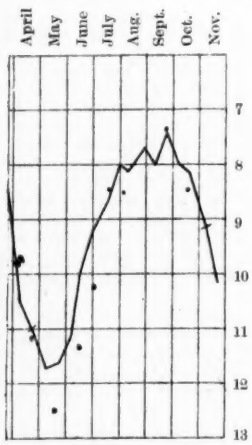



Fig. 3.—The black dots correspond to the magnitude of *S. Ursæ Majoris* as determined by Mr. O. C. Wendell, of Harvard. The curve to the Rousdon observations in 1889.

It has been suggested by Mr. Lockyer that the variation in the light of these stars may be due to the impact of meteors—moving in elliptic orbits—but such motion would give rise to maxima at regular intervals of time when the thickest part of the swarm came up to the region of collision.

The suggestion that the variation in the light may be due to phenomena in these stars similar to the spots on our sun seems far more probable; though we must conceive of the development of spots on these stars much larger than those with which we are acquainted on the sun. Most of these variable stars are reddish, and more particularly red at their minima, and their spectra have a greater analogy with the spectra of sun-spots than with the spectrum of the photosphere.

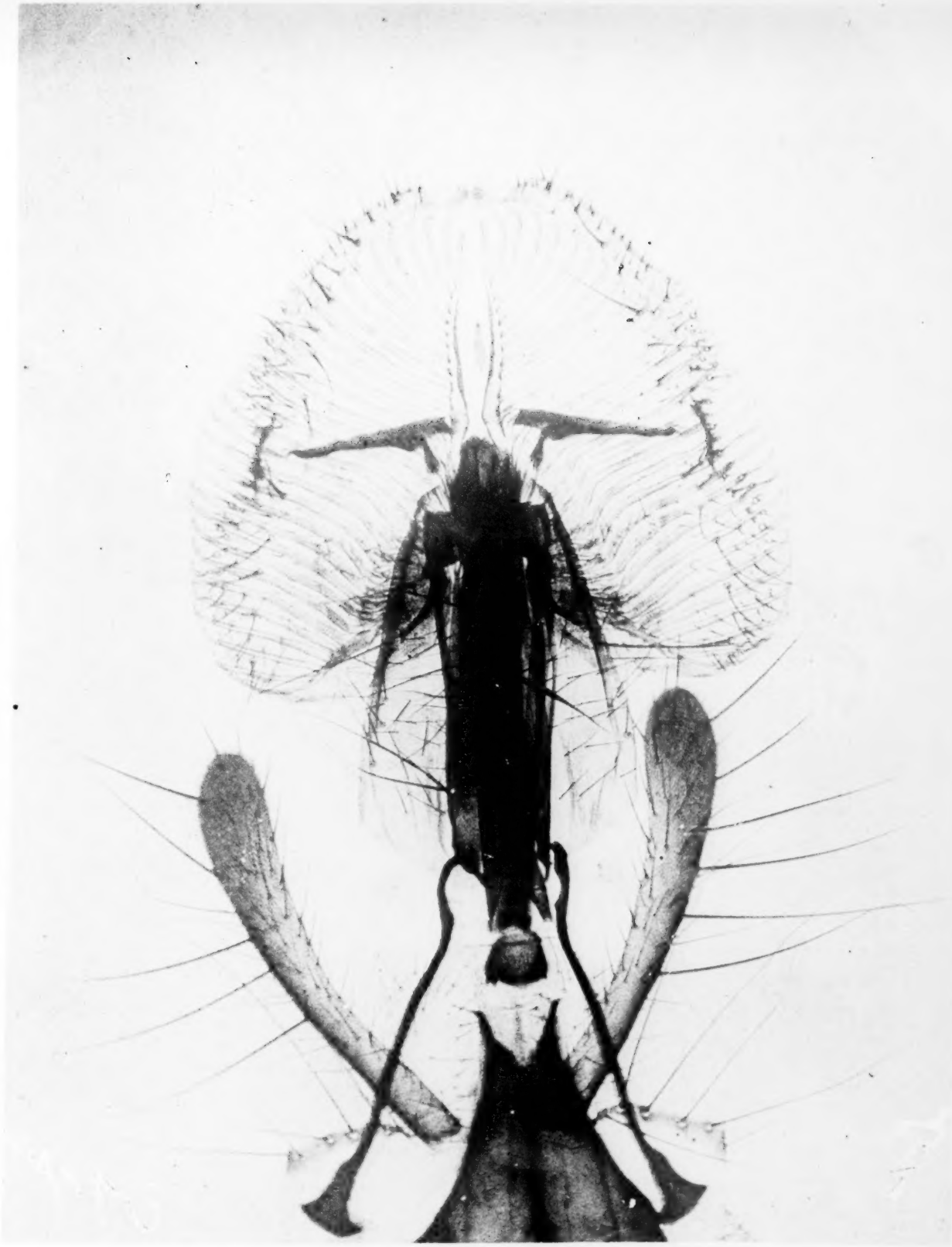
Frequent reference has been made to a nebulous appearance which is occasionally seen about some of these variable stars, especially *S. Cassiopeiæ*, *R. Cassiopeiæ*, and *S. Coronæ* (see also Knowledge for March 1869, p. 104). An examination of the Rousdon observations shows that such nebulous appearances are not confined to periods of maxima or minima of the star's variation in light. When plotted upon the star curves they are found to be irregularly placed, sometimes being seen near to minima as well as maxima and sometimes intermediately between the two. The phenomenon is always described as "a bluish nebulous haze." It is possible that the star may be always surrounded by such a haze of light corresponding to the extreme violet end of the spectrum. But that the transparency of the atmosphere for such violet light varies from time to time. The light round *Maia* and *Electra* in the Pleiades Group seems to be of this character, and to have been just glimpsed on favourable occasions by some observers, though most fail to see it even now that its existence is demonstrated by photographs.

Mr. Peek proposes to publish his observations, probably in atlas form, when he has observed five complete periods of the 600 day variables under observation.

## WEIGHING A DOUBLE STAR.

In Prof. E. C. Pickering's third Annual Report of the Draper Memorial work, a very interesting fact is noted in connection with the spectrum of *ζ Ursæ Majoris*, of which more than 70 photographs have been taken. It has been found that the K line appears doubled at intervals of 52 days, beginning from March 27, 1887, and that for several days before and after the dates on which it appears doubled the line presents a hazy appearance. The other lines in the spectrum are much fainter, and, although well shown when the K line is clearly defined, are seen with difficulty when it is hazy. Several of them are certainly double when the K line is double. Measures of the plates give a mean separation of 0·246 millionths of a millimeter for a line whose wave-length is 448·1 when the separation of the K line, whose wave-length is 393·7, was 0·199. As Prof. Pickering remarks, the only satisfactory explanation of this phenomenon is that the brighter component of this star must be a double star having components nearly equal in brightness and too close to have been separated as yet visually, and that the time of revolution of the system is 104 days. When one component is approaching the earth, all the lines in its spectrum will be moved towards the blue, while all the lines in the spectrum of the other component will be moved in the opposite direction. When the motion becomes perpendicular to the line of sight, the lines recover their true wave-length and become single.

The relative velocity as derived from one set of measures comes out as 94 miles a second, and as 102 miles per second from another set. If the orbit is circular and its plane passes through the Sun, the distance travelled by one component in 52 days, regarding the other as fixed, would be about 900 million miles; and the distance apart of the two components would be 143 million miles, or about equal to that of Mars from the Sun. The combined mass of



**TONGUE OF FLY.** Magnified about 130 diameters.

Photographed from the under side, showing the hard parts only. The club-shaped appendages are the Maxillary Palpi, and the dark pieces crossing them, rods to which muscles are attached. The Mouth is situated at the upper end, just above the dark mass in the centre. The rays in the heart-shaped piece at the upper end are sucking grooves, and where they join the central dark mass some teeth may be seen.

*Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.*

XUM

the two must be about 40 times that of the Sun to give the required period; and if the orbit is inclined to the line of sight the dimensions of the orbit and the corresponding masses must be greater.

In a later postscript, written on Jan. 11th, Prof. Pickering says that the period of *ζ Ursæ Majoris* appears to be 52 days instead of 104, and that its orbit is noticeably elliptical.

A similar phenomenon has also been observed with regard to the spectrum of *β Aurigæ*. The velocity of its components seems to be 150 miles per second, and their period 4 days; their orbit nearly circular. If its plane passes through the Sun, it must have a radius of 8 million miles, and their joint masses must be about one-fifth of the mass of the Sun.

## Notices of Books.

*The Alternate Current Transformer in Theory and Practice.* By J. A. Fleming, M.A., D.Sc. (London: The Electrician Printing and Publishing Company, 1889.) In one of the various systems of electric lighting, the electricity generated by the dynamo machines at the central station is sent along the mains not in one continuous current flowing always in the same direction, but in a series of momentary currents alternating in direction. The electromotive force driving these currents in the mains is very high. For economical reasons it is necessary that the intensity (if the use of a somewhat discredited word may be permitted) of the currents employed in the mains should be much greater than that of the currents employed in the houses. Therefore, at the junction from which the wires are led into a house from the main, a "transformer" or "converter" is placed, an instrument designed to "transform" the main current into a current considerable in point of quantity, but having a lower electromotive force. This instrument is essentially a form of induction coil, consisting of a soft iron core round which are wrapped two coils of insulated wire, one long and thin and the other short and thick. The primary currents in the main pass through the former coil and induce secondary currents of the required strength in the latter.

In the forthcoming second volume of his book Dr. Fleming proposes to deal with the construction, design, and use of induction transformers, their application in electric lighting, welding, and technical work, and the subject of practical measurement. The volume before us, while nominally devoted to an exposition of the theory of alternating currents in transformers, is in reality a great deal more than this. It is a most complete and very valuable treatise upon the phenomena connected with the interaction of electric currents, the nature of periodic currents, and electromagnetic induction. For the laws governing the action of a transformer are of so complicated a nature that any discussion of them must inevitably extend over the whole field of electromagnetism, and it is a striking instance of the beneficial influence of commercial requirements upon scientific advance that the practical needs of electric lighting should have driven physicists to the careful study and elucidation of this most difficult department of science. When a continuous current is flowing in a wire, we know that its strength depends upon the resistance of the circuit; but when the current is rapidly reversed and is "periodic," it encounters other obstacles in its path besides resistance. Not only is the resistance of the circuit increased, but a certain inertia has to be overcome, an inertia which is to be looked for not in the current itself but in the mechanism (whatever it may be) by means of which the electrical action is propagated through the dielectric. During the operation of transformation in the transformer other phenomena arise, such as magnetic hysteresis and those "eddy currents" in the iron cores to which Dr. Fleming applies the epithet "parasitical." These and other matters receive as complete an exposition at Dr. Fleming's hands as the present state of electrical knowledge admits of. His book is not written for tyros, but should be readily followed by anyone who has mastered the elementary text books. Commencing with the "ten days of splendid and conclusive experiment" in which Faraday in 1831 discovered the laws of current induction and the facts of magneto-electricity, he conducts the student by easy stages to a point of vantage from which he can see all that has been added to the theory of electromagnetism up to the present day. The experiments of Professor Henry, who enunciated the principle of the transformer fifty years ago, and the investigations of Blaserna, Professor Hughes, Lord Rayleigh, Mr. Heaviside, and others, are given in considerable detail. And we see no reason to complain because in the course of his exposition the author uses the notation of the calculus. As he himself says (p. 88), "it is generally easier to master the elements of the infinitesimal calculus than to construct or follow proofs which aim at avoiding its use."

To an electrical engineer the first four chapters of the book will doubtless be the most useful, but those who are not commercially interested in electricity will perhaps be more attracted by the chapter on Dynamical Theories of Current Induction which fills the last 150 pages. Here we have a very clear account of the marvellous imaginary mechanical model devised by Clerk Maxwell, as many as thirty years ago, to illustrate the manner in which it is possible that electric influence is exerted. Maxwell imagined that all space is filled with spherical elastic bodies capable of rotation. These he called "molecular vortices," infinitely smaller than the molecules of matter. The vortices he supposed to rotate about the lines of force as axes, exerting a tension along the lines of force and a pressure at right angles to them. As all the vortices in a given portion of a magnetic field were supposed to rotate in the same direction, it was necessary to imagine that other and infinitely smaller bodies were interposed between them, which might serve the same purpose as "idle wheels" in machinery. It would be impossible within the limits of this notice to explain in detail how, by means of this theory, all the complex phenomena of electromagnetism may be correlated, and how the theory is largely borne out by experimental comparisons of the specific inductive capacities of dielectrics with their indices of refraction. We would, however, direct attention to the paragraphs in which Dr. Fleming explains how it is that the ratio between the electrostatic and electromagnetic units of electricity is "a velocity," that this velocity is the velocity of the transmission of transverse vibrations through the ether, and that the measurements of Maxwell and others show this velocity to be about the same as the velocity of light. It is particularly interesting to read this very lucidly written account in connection with the recent investigations of Professor Lodge and the young German, Dr. Hertz, into the oscillatory character of electric discharges, a full description of which is given. The study of this very interesting chapter is well calculated to inspire the student with some share of that scientific enthusiasm which at the present time is leading physicists to the elucidation of some of the more abstruse problems of electricity.

XUM

# Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

## COMETS.

*To the Editor of* Knowledge.

Sir,—Mr. Barnard's article in your February number is interesting, and many of your readers will hope that it may prove true. I hardly expect it, however. The fact is, that comets (and to a certain extent asteroids) have a tendency to congregate in families and one member of the family is apt to be mistaken for another. Thus Finlay's comet was at first mistaken for De Vico's (of 1844), and I find the error recurring in my friend Mr. Gore's lately published book, *The Scenery of the Heavens*. It is a curious fact, however it may be accounted for, that no comet the inclination of whose orbit to the ecliptic is as small as in the case of Lexell's, De Vico's, or Finlay's, has up to the present been known to return.

My object in writing, however, is a somewhat different one. The connection between four known comets and four known meteor-showers has led many astronomers to conclude that a comet is nothing but a dense shower of meteors. Now, the closest approach that any comet is known to have made to the earth was that of Lexell's comet in 1770. I do not find that any shower of meteors was observed on that occasion. In the year 1826 the earth is believed to have passed through the tail of a comet; but I do not find any meteor-shower recorded. Several other comets, particulars of which will be found in any catalogue, made a close approach to the earth without producing any meteor-shower. In short, it seems to me as unphilosophical to conclude on the present evidence that a comet consists of clouds of meteors, as it would be to conclude that a planet does so because this is the most probable explanation of Saturn's rings. Saturn, so far as we know, is the only planet that has a ring; and only four comets, so far as we know, have an attendant meteor-system.

As regards the four comets in question, we have only met the meteors at a considerable distance from the comet. If we could go closer to it, we might meet more, or we might meet none. At all events no shower that we have as yet encountered has been dense enough to produce observable collisions among the component meteors. The theory that collision of meteors is the cause of any of the light which we observe, has yet to be verified by experience.

Truly yours,
W. H. S. Monck.

[But the orbits of all these four comets approach the earth's, and the similarity of the inclination, period, and eccentricity, in each case makes the coincidence at least very remarkable. We know that many meteor streams are enormously broad—the earth taking days to pass through them—and that in several cases attendant comets move in the same orbit with a larger one. No one assumes that the tail of a comet is composed of meteors.—A. C. Ranyard.]

*To the Editor of* Knowledge.

Sir,—With your permission, I should like to point out a misleading statement in one of Mr. Christie's original and suggestive papers on the Properties of Numbers. When we speak of possessing a *test* for a thing, it is naturally supposed that it is a test not only for the presence but also for the *absence* of the thing in question. Any other kind of test is almost valueless. Suppose a test for arsenic were announced, and that whenever it produced a certain effect, the presence of the poison was demonstrated; but when the effect was *not* produced, the case was *doubtful*—there might, or might not, be arsenic present. Such a partial test would be of limited value.

Now, Mr. Christie, in the February number, p. 73, states that certain simple processes are *tests* of divisibility by 7, 11, 13, and other prime numbers. With the exception of that relating to 11, all the others are of the partial kind I have alluded to. He tells us quite correctly (*e.g.*) that when every third figure in a number is added together and the sums are alike, 37 exists as a factor. But to say that this is a test for the divisibility by 37, is misleading, as it would naturally, but incorrectly, be inferred that when the third figures do *not* add alike, 37 is *not* a factor. But in the vast majority of the multiples of 37, the third figures do not sum uniformly. Here are two for example: 262774259 and 973112691.

Whilst I am writing, perhaps I may be permitted to point out a mistake in the July paper, p. 187. I think Mr. Christie will find that his statement (at top of second column) with regard to the number 19 is incorrect, and that there are 18 prefixes—not 9 only. They are 17, 15, 11, 3, 6, 12, 5, 10, 1, 2, 4, 8, 16, 13, 7, 14, 9, 18; and they recur after N−1 values, *not* $\frac{N-1}{2}$. And four lines lower down, I think he should have written (to be consistent with the previous section)—"Our formula for seven is $7.r-5^n r$, *i.e.* $7\times18-5^3\times1=1$,"

I scarcely like to criticise further these interesting papers, but I might just say that it is a not so very curious fact (Jan. p. 46) that the repetend of a circulating decimal (when the denominator is a prime number greater than 5) should be divisible by 9. A repetend is the quotient got by dividing a series of nines by a prime number. Now, when a dividend is divisible by 9, and the divisor prime to 9, the necessary result is that the quotient is divisible by 9.

I look forward with interest to the paper on *remainders*, that Mr. Christie has promised us at a future time.

Yours faithfully,
T. S. Barrett.

*To the Editor of* Knowledge.

## MAGNITUDE OF STARS.

Sir,—In looking over the deeply interesting diagram showing the distances of the fixed stars, in your last number, I should like to ask if you could give a rule whereby to estimate the relative size of the stars. When we observe such stars as $\alpha$ Bootis, $\beta$ Centauri, $\alpha$ Lyræ, $\alpha$ Argus maintaining their character as stars of the first degree of magnitude at distances so enormous compared to those of other first-magnitude stars, such as $\alpha$ Centauri, or Sirius, we are forced to conclude that their real magnitudes must be something so great that our imagination is baffled to realise it.—Yours truly,

Tynron, Scotland. J. S.

[The black discs in the diagram are intended to represent the brightness of the stars, and not their actual magnitude. No star disc has yet been measured, and it is evident that stars differ greatly in actual brightness, thus Sirius has a companion of the tenth magnitude which causes marked irregularities in the proper motion of the

brighter star. If Sirius and its companion had equally bright surfaces, the larger star would have an area about 10,000 times as great as the smaller star, for Sirius is certainly ten magnitudes larger than its companion; and if the densities of the two bodies were similar, the mass of the larger star would be about one million times as great as that of the companion. But the inequalities in the proper motion of Sirius show that the mass of the companion must be considerable compared with that of the primary. The companion must therefore be a comparatively dark body. *Algol* and other stars of its class must also have comparatively dark companions. The great difference in the brightness of 61 *Cygni* and *α Centauri* points to the conclusion that one of these pairs of stars must either be very much larger or very much brighter than the other. We cannot, therefore, safely make any estimates as to the size of stars from their brightness.—A. C. Ranyard.]

### A GRUB IN A BOTTLE OF WINE.

*To the Editor of* Knowledge.

Dear Sir,—As I was a short time ago pouring out a glass of port wine, I saw in the glass a small grub about a quarter of an inch in length. I felt quite sure that it came out ot the bottle, but could not quite make out how it got there. I took it out and put it away carefully, and nex day tried it with different kinds of food. Finding that it would not touch green food, I thought that possibly it might have come out of the cork. I therefore gave it some small pieces of cork, but it seemed quite as unacquainted with this substance as with the green food. I next tried a drop of port wine. To this it went immediately, and existed upon it for a day or two, when, through my carelessly omitting to renew the supply, it died.

I had, however, proved to my satisfaction that it had been living in the wine before the time when I first made its acquaintance. I have since heard that there is a fly which lays its eggs in port wine. But I should like to ask whether any of your readers can inform me how the egg was laid, and whether the grub had been in the wine for the seven years during which it was supposed to have been bottled? How, in the ordinary course of things, does the grub become a chrysalis and prolong its existence?

Yours faithfully,

G. C. G.

*To the Editor of* Knowledge.

Dear Sir,—Your excellent article on Harvard Observatory in a former number has recalled to my mind a subject that once excited much curiosity, and may still possess some interest for many of your readers.

Before the first Atlantic cable was laid the only means of determining the difference of longitude between the Observatories of Greenwich and Cambridge, near Boston, was by the transport of chronometers. Every steamer then running between Liverpool and Boston carried several chronometers, and the results of the trials were very perplexing. The outward-bound voyages grouped themselves around one point, and the homeward-bound around another and different point. What I wish to ask is—(1) Has this singular discrepancy ever been satisfactorily accounted for; and (2) which series approached nearer the truth?—Yours faithfully,

John Kenny.

Glasheen, Cork, 14th February 1890.

## THE FACE OF THE SKY FOR MARCH.

By Herbert Sadler, F.R.A.S.

A FEW sunspots, and those mainly of small size, appear at intervals on the solar disc. The Zodiacal light may be looked for on moonless nights, after the last traces of twilight have disappeared, in the form of a faint spindle-shaped or lenticular cone of light extending from that part of the heavens where the sun has set to about 45° or 50° in length, and forming an angle of about 60° with the horizon. Conveniently observable minima of Algol occur on the 7th at 11h. 42m. P.M.; on the 10th at 8h. 43m. P.M.; and on the 30th at 10h. 13m. P.M. Mercury is a morning star during the first half of the month, but is badly situated for observation, owing to his proximity to the sun, and his great southern declination. During the last half of the month he will be too near the sun to be visible. On the 1st he rises at 6h. 0m. A.M., or 47 minutes before the sun, with an apparent diameter of $6\frac{1}{2}''$, and a southern declination of 17°. On the 12th he rises at 5h. 55m. A.M., or 28 minutes before the sun, with an apparent diameter of $5\frac{1}{3}''$, and a southern declination of 13°. He is in aphelion at 6 P.M. on the 5th. Mercury is in Capricornus until the 9th, when he enters Aquarius; but he does not approach any conspicuous star very closely while visible just before sunrise. Venus will be too near the sun to be visible during the first three weeks of the month. On the 31st she sets at 7h. 26m., or 57 minutes after sunset, with an apparent diameter of 10″, and northern declination of $7\frac{1}{4}°$. While visible she is in Pisces, but does not approach any conspicuous star. Mars is a morning star, rising on the 1st at 0h. 55m. A.M., with an apparent diameter of 10″, and a southern declination of 19°. On the 31st he rises at 11h. 52m. P.M., with an apparent diameter of 14″, and a southern declination of $21\frac{1}{4}°$. He is in Scorpio throughout the month, being 8′ due north of the $2\frac{1}{2}$ magnitude star $\beta^1$ Scorpionis at 4h. A.M., on the 5th, but does not approach any other conspicuous star. His disc will be seen to be distinctly gibbous. Jupiter is a morning star, rising on the 1st at 5h. 24m. A.M., or 1h. 24m. before the sun, with a southern declination of 20° 10′, and an apparent diameter of 32″. On the 15th he rises at 4h. 37m. A.M., with a southern declination of $19\frac{1}{2}°$, and an apparent diameter of 33″. On the last day of the month he rises at 3h. 40m. A.M., with an apparent diameter of 34″, and a southern declination of 19°. No eclipses, occultations, or transits of the satellites occur, while the planet is 8° above, and the sun 8° below the horizon; but from the time of the planet's rising on the 8th until sunrise, only one satellite (the second near its western elongation) will be visible, the first and fourth being under eclipse, and the third transiting the planet's disc. Jupiter is in Capricornus during the month, but does not approach any naked-eye star very closely. Saturn is well situated for observation, setting on the 1st at 6h. 47m. A.M., and rising at 4h. 21m. P.M. the previous evening with a northern declination of 13° 11″, and an apparent diameter of 18″ (the major axis of the ring system being 45″ in diameter, and the minor 8″). On the last day of the month he rises at 9h. 25m. P.M., with a northern declination of 10° 2′, and an apparent diameter of $17\frac{1}{2}''$. Shortly after 9 A.M. on the 2nd Iapetus will transit the planet's disc, the egress taking place about 3 P.M.; the phenomenon, however, will not be visible in England. On the evening of the 2nd Iapetus will be in conjunction with the preceding end of the ring, and 4″ south of it. On the evening of the 7th Titan will be about 45″ *n.f.* the planet, and on the 16th about the same distance *s.f.* When setting on the 23rd Titan will be about

XUM

40″ *n.f.* the planet. Saturn describes a short path in Leo during the month, in a region barren of naked-eye stars. Uranus rises on the 1st at 9h. 44m. P.M., with a southern declination of 9° 35′ and an apparent diameter of 3″·8. On the 31st he rises at 7h. 43m. P.M., with a southern declination of 8° 45′, and an apparent diameter of 4″·0. He describes a short path in Virgo during March, a map of his path from February 1st to July 31st being given in the *English Mechanic* for February 7th. He is as bright as a $5\frac{1}{2}$ magnitude star. Neptune is approaching the west, setting on the 1st at 1h. 9m. A.M., with a northern declination of 18° 57′, and an apparent diameter of 2″·5. On the 31st he sets at 11h. 15m. P.M. He describes a small arc in Taurus throughout the month, moving in a short path to the west of 43 Tauri, and approaching that star. There are no very well marked showers of shooting stars in March. The Moon will be full at 6h. 48m. P.M. on the 6th, enters her last quarter at 4h. 5m. A.M. on the 14th, is new at 9h. 1m. P.M. on the 20th, and enters the first quarter at 9h. 33m. A.M. on the 28th. At 10h. 3m. P.M. on the 1st the 6th magnitude star 58 Geminorum will disappear at an angle of 66° from the vertex, and reappear at 11h. 4m. P.M. at an angle of 337°. At 0h. 19m. A.M. on the 10th the 6th magnitude star B.A.C. 4647 will make a near approach to the lunar limb at an angle of 306° from the vertex. At 7h. 7m. A.M. on the same day the 6th magnitude star 95 Virginis will disappear at an angle of 98° from the vertex, the sun having risen nearly 40 minutes at the time, and reappear at 8h. 10m. A.M. at an angle of 290° from the vertex, the star being below the horizon at the time when it should re-appear; and at 7h. 11m. A.M. on the same morning the 6th magnitude star 94 Virginis will make a near approach to the lunar limb at an angle of 192° from the vertex. At 5h. 3m. A.M. on the 15th the 6th magnitude star B.A.C. 6369 will disappear at an angle of 28° from the vertex, and reappear at 6h. 2m. A.M. at an angle of 292°. At 8h. 0m. P.M. on the 25th the 6th magnitude star B.A.C. 1361 will make a near approach at 51° from the vertex, and at 9h. 53m. P.M. the same evening the $3\frac{1}{2}$ magnitude star $\epsilon$ Tauri will make a near approach at an angle of 49°. At 9h. 2m. P.M. on the 26th the 6th magnitude star 109 (*n*) Tauri will disappear at an angle of 191° from the vertex, and reappear at 9h. 40m. P.M. at an angle of 261°. At 0h. 41m. A.M. on the 27th the 6th magnitude star 114 Tauri will disappear at an angle of 118° from the vertex, and reappear at 1h. 32m. A.M. at an angle of 312°, the star having set at the time. At 7h. 40m. P.M. on the 27th the 6th magnitude star 3 Geminorum will disappear at an angle of 82°, and reappear one hour later at an angle of 349° from the vertex; and at 9h. 41m. the same evening the 6th magnitude star 6 Geminorum will make a near approach at an angle of 40° from the vertex. At 1h. 10m. A.M. on the 30th the $6\frac{1}{2}$ magnitude star 7 Cancri will disappear at an angle of 84° from the vertex, and reappear at 1h. 58m. A.M. at an angle of 330° from the vertex.

## Whist Column.

By W. Montagu Gattie.

WE now give, as usual, an elementary explanation of the play of the hand published in the February number of Knowledge. For convenience of reference, the distribution of the cards is here repeated; A and B being partners against Y and Z, A having the first lead, and Z (the dealer) having turned up the eight of diamonds.

| A's Hand. | B's Hand. |
|---|---|
| D.—Ace, 7. | D.—Kg, Qn, 9, 4. |
| C.—Ace, 8, 4. | C.—Qn, Kn, 7. |
| H.—Kn, 10, 8, 5, 3. | H.—9, 4. |
| S.—10, 4, 2. | S.—Ace, Qn, Kn, 8. |

| Y's Hand. | Z's Hand. |
|---|---|
| D.—Kn, 10, 6, 3. | D.—8, 5, 2. |
| C.—5, 2. | C.—Kg, 10, 9, 6, 3. |
| H.—Ace, Kg, 6, 2. | H.—Qn, 7. |
| S.—9, 7, 3. | S.—Kg, 6, 5. |

*Trick* 1.—A opens with the lowest card of his longest suit. Most players now-a-days would lead the lowest but one; and an attentive partner, on seeing the lowest card fall afterwards (Trick 6), would know the lead to have been from a suit of at least five cards (see Knowledge, Vol. XII., p. 155). Y wins the trick, according to rule, with the lower of two indifferent high cards. B infers that A is strong in hearts; and, as he has good trumps, and is fairly protected in the other two suits, he commences a "call" by playing the nine of hearts instead of the four. But, although these circumstances might, not unreasonably, be held to justify his leading trumps himself, they are not a sufficient defence for his calling upon his partner to do so, and thereby, it may be, causing him to sacrifice his own game entirely. The student should be on his guard against an indiscriminate use of the signal for trumps. It is a tolerably certain inference from this trick that Y holds the ace of hearts, for he would not otherwise play the king second in hand, unless he had no other card of the suit, and the latter alternative is not at all probable seeing that B and Z have both played high cards.

*Trick* 2.—Here we have an instance of a forced lead from weakness. Y's strongest suit is hearts; but A has shown that he also has strength in that suit, so that it would clearly be bad play for Y to give up the command by leading out the ace. He is not strong enough to lead trumps, and, therefore, is reduced to opening either clubs or spades. He leads the five of clubs in accordance with the rule that the highest should be led from a suit of two or three cards. B, holding queen, knave, and one other club, correctly plays the knave. With four cards of the suit, it would be right to play a small one. Z, of course, heads the knave with his king, and A wins with the ace. It is now clear to Y that the queen of clubs is against him, for, if it were in Z's hand, he would have played it instead of the king.

*Trick* 3.—A takes his partner's nine of hearts (trick 1) to have been the commencement of a call for trumps, and it so happens that he is right. But there is no reason why B should not hold the queen of hearts, or he may have no more hearts at all, so that it would be much better and safer play for A to continue the heart suit. However, as he determines to lead trumps, he plays correctly in beginning with the ace, his object being to assist B's hand as much as possible.

*Trick* 4.—A, of course, continues the trumps, and Y plays the ten, as this must draw an honour, after which he will remain with knave guarded.

*Trick* 5.—B, after making his queen of trumps, somewhat rashly continues with the king. He would have done better to open his spades. After this trick the knave of trumps is marked in Y's hand. A plays badly in discarding a spade. His ten of spades is the only card in his hand, except the hearts, with which he can reasonably expect to win a trick, and it should therefore be kept guarded as long as possible.

XUM

*Trick* 6.—B returns his partner's original lead. Y wins Z's queen with the ace in order to draw B's losing trump. We have already stated our opinion that it would have been better to leave the trick with Z. There are very few cases in which it is right to abandon the command of an adverse suit.

*Trick* 7.—Y draws the trump, and Z and A have to discard. Z has not yet had a lead, and has so far had no opportunity of indicating his strong suit. He can now do this by discarding a spade, which would be equivalent to asking his partner to lead clubs. He fears to do this on account of weakening his king of spades. But he should remember that the effect of his discarding a club will be that Y will lead a spade; and that is certainly not what Z wants, for he cannot even tell that the ace of spades is not with A, and anyhow he wishes to retain his king for use as a card of re-entry when his clubs are established.

*Trick* 8.—Y properly leads his best spade, in accordance with Z's discard.

*Trick* 9.—Z holds the second and third best clubs, and by leading one of them forces out the queen and remains with the command, which enables him to win the thirteenth trick, and so save the game. The beginner should observe that, if Z had inadvertently led a small club at this point, AB would have made all the remaining tricks.

## Chess Column.

By W. MONTAGU GATTIE.*

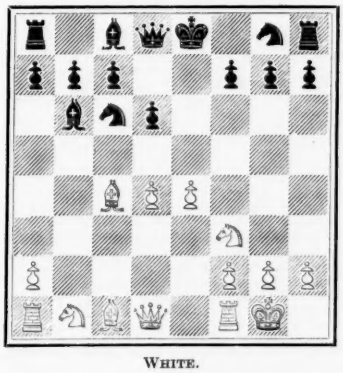
[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

### THE EVANS GAMBIT.

WHAT is usually known as the "normal position" in the Evans Gambit is arrived at by several courses of play, of which the following is the most common:—

| WHITE. | BLACK. |
|---|---|
| 1. P to K4 | 1. P to K4 |
| 2. Kt to KB3 | 2. Kt to QB3 |
| 3. B to B4 | 3. B to B4 |
| 4. P to QKt4 | 4. B × P |
| 5. P to B3 | 5. B to B4 |
| 6. Castles | 6. P to Q3 |
| 7. P to Q4 | 7. P × P |
| 8. P × P | 8. B to Kt3 |

BLACK.



WHITE.

White has now several methods of continuing the attack, one of the most forcible of them being—

9. Kt to B3

to which the recognised reply is—

9. Kt to R4

At one time it was held that White should answer this by 10. KKt to Kt5, leaving the Bishop to be taken, and recovering the piece by checking with his Queen at R4. But this course was found to result in loss of time, as well as of an important attacking piece; and later analysis showed that it was better for White to retreat his menaced Bishop to Q3, a line of play resulting in what is generally called "Anderssen's Defence." Still more recently the question of abandoning the Bishop has been reconsidered in connection with—

10. B to KKt5

but this variation did not become widely known until its successful adoption by M. Tschigorin against Mr. Steinitz in the celebrated London Tournament of 1883. On that occasion the game proceeded thus:—

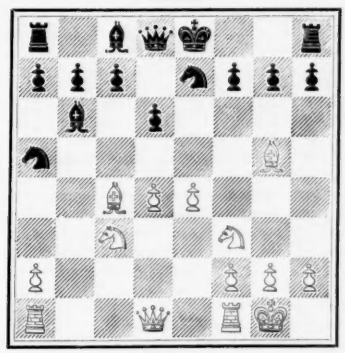
| | |
|---|---|
| | 10. P to KB3 |
| 11. B to B4 | 11. Kt × B |
| 12. Q to R4 ch | 12. Q to Q2 |
| 13. Q × Kt | 13. Q to B2 |
| 14. Kt to Q5 | |

Mr. Steinitz, in his notes to the game, remarks that White's fourteenth move is "a strong continuation"; and, although much attention has been bestowed on the position, no reply has yet been discovered that relieves Black from embarrassment (14 . . . B to K3 seems the most hopeful), nor does it appear that any of his previous moves can be altered with advantage.

It is, however, quite feasible to meet 10. B to KKt 5 with

10. Kt to K2

BLACK.



WHITE.

White's best course is considered to be

11. Kt to Q5

in answer to which Black has the choice of 11 . . . P to KB3 and 11 . . . Kt × B. In the first alternative he is subjected to a furious onslaught by 12. B × P, P × B; 13. Kt × P ch, K to Bsq; 14. Kt to Kt5, &c.; and probably his safest line of play is—

| | |
|---|---|
| | 11. Kt × B |
| 12. B × Kt | 12. Q to Q2 |
| 13. B to B6 | 13. Q to Kt5 |

Better than 13 . . . Castles, which leads to 14. Q to Bsq, Q to Kt5, 15. Kt to K7 ch, K to Rsq, 16. Q to R6, &c. White's best reply to 13 . . . Q to Kt5 is still an open question, and the game is certainly very difficult for both parties.

In the ninth game of the match just concluded between Messrs. Gunsberg and Tschigorin, Mr. Gunsberg, as second player, answered his opponent's favourite attack with 10 . . . Kt to K2 (see the second diagram), instead of 10 . . . P to KB3, as played by Mr. Steinitz; upon which M. Tschigorin, instead of playing the "book move" 11. Kt to Q5, entered upon the following dashing variation:—

| WHITE. M. Tschigorin. | BLACK. Mr. Gunsberg. |
|---|---|
| 11. B × P ch | 11. K × B |
| 12. Kt to Q5 | 12. QKt to B3. |

* Mr. Montagu Gattie has kindly undertaken the chess column during the progress of Mr. Gunsberg's match with M. Tschigorin in Havannah.—EDITOR.

Here Black, who was probably taken by surprise, compromised his game. It was essential to prepare a haven for his King without delay, and, as will presently appear, the services of the Queen's Knight were required at QR4, in order to prevent White from stationing his Queen at her Knight's third square. The only sound move was 12. . . . R to Ksq. which which would have resulted in Black's retaining two pieces against a rook, with a perfectly defensible position. The actual game proceeded—

| | |
|---|---|
| 13. B × Kt | 13. Kt × B |
| 14. Kt to Kt5 ch | 14. K to Kt3 |

The error of Black's 12th move is now apparent. His King is driven into the open. If he were to seek refuge at Ktsq, White would force the game by 15. Q to Kt3; and, if at Bsq or Ksq, 15. Q to R5 should win.

| | |
|---|---|
| 15. Kt to B4 ch | 15. K to B3 |

If 15 . . . K × Kt, White wins by 16. Q to R5 ch and 17. P to K5 ch.

| | |
|---|---|
| 16. P to K5 ch | 16. P × P |
| 17. P × P ch | 17. K × Kt |
| 17. Q to R5 ch | 18. K × Kt |
| 19. P to Kt3 ch | 19. K to K5 |
| 20. KR to Ksq ch | 20. K to Q5 |

If 20 . . . K to Q4, then 21. P to K 6, dis. ch.

21. Q to Qsq ch

Up to this point White's play has been of the highest order, and he has the game in his hands. But this move betrays want of care. He had only to play 21. QR to Bsq, which would have left Black practically without resource.

21. K to B4

22. Q to B2 ch

Another lapse. White could have forced mate in seven moves by 22. R to QBsq ch, K to Kt4, 23. Q to Kt3 ch, K to R3, 24. R to B5, B × R, 25. Q to R4 ch, K to Kt3, 26 R to Ktsq ch, B to Kt5, 27. Q × B ch, K to B3, 28. Q to Kt5, mate.

| | |
|---|---|
| | 22. K to Q4 |
| 23. Q to Kt3 ch | 23. K to B3 |
| 24. Q to R4 ch | 24 K to Q4 |

Owing to White's indifferent play, the Black King is now out of danger and, in view of the disparity of forces, White's best course would no doubt have been to secure a draw by perpetual check. Probably through vexation at having let the game slip, he tried to win by QR to Qsq ch, followed by Q to Kt4 ch and R × Q.

The remainder of the game presents no special feature of interest, Mr. Gunsberg being able by careful play gradually to develop his superior force, and by a judicious sacrifice of a piece to avert any danger from the advance of the White pawns.

M. Tschigorin resigned on his 46th move.

"Alpha" sends us the following problem for solution:—

White:—K at QKt8, Rs at Q3 and QB8, Bs at K4 and KR8, Kts at KB7 and QB6, Ps at K2 and QR7.

Black:—K at QB5, Rs at Q8 and QKt7, Kt at KR3, Ps at KB4, K2, K3, Q7, QKt6, QR3, and QR4.

White to play, and mate in three moves.

The solution appears to be:—

| | |
|---|---|
| 1. R to Q5 | 1. P × B, or (A), or (B), or (C), or (D) |
| 2. B to B3 | 2. K × B, or K or P × R |
| 3. R or Kt (B3) mates accordingly. | |

A.

| | |
|---|---|
| | 1. P × R |
| 2. B to Q3 (ch) | 2. K to B4 |
| 3. B to Q4, mate | |

B.

| | |
|---|---|
| | 1. Kt × Kt |
| 2. B to Q4 | 2. Anything |
| 3. B or R mates accordingly | |

C.

| | |
|---|---|
| | 1. P to K4 |
| 2. Kt (B7) × P (ch) | 2. K to B6 |
| 3. R mates | |

D.

| | |
|---|---|
| | 1. R (Kt7) moves |
| 2. B to Q3 (ch) | 2. K × R |
| 3. Kt × KP, mate | |

The second volume of the new series of shilling hand-books on games now being published by Messrs. Bell & Sons is devoted to an elementary treatise on chess, by Mr. R. F. Green.* Mr. Green's competence to deal with his subject has already been abundantly proved by his able editing of the *British Chess Magazine*. His aim, as stated in the preface, "has been to provide a thoroughly complete and practical series of lessons in chess. The reader is assumed at the outset to be without any knowledge whatever of the game, and the attempt is made to teach him how to play, and to leave him in a position to profit by the most advanced treatise." Starting with this object, Mr. Green has succeeded in producing a most useful and trustworthy little book, which is certainly the best that we have seen of its kind for beginners, and also contains much information of value to players who have made some progress towards proficiency. It is needless to say that no written precepts, however simply and clearly expressed, can altogether supply the place of oral tuition; but Mr. Green evidently has the faculty of anticipating a tyro's difficulties, and has done his best to remove these by a lucidity of treatment and a methodical arrangement too often wanting in more pretentious works. It seems a pity that more space is not allotted to the "scheme of the openings," as the variations stop short too soon to be of much service to the student; and it would be well, we think, in future editions, to spare a few pages to an elementary analysis of some of the leading *débuts*, such as the Evans Gambit, the Scotch Game, the Knight's Game of Ruy Lopez, the Allgaier Gambit, and the Vienna Game, at any rate as far as the first eight moves on each side, together with a brief exposition of the leading principles of the "close game." Compared with the slight attention given to the openings, the chapter on End-Games strikes us as somewhat diffuse, although it is premised that only elementary endings are considered. The method of winning with King, Knight, and Bishop, against King is almost beyond the grasp of a beginner, and might have been omitted; and we must here record our dissent from the old theory that a corner square not commanded by the Bishop is the most favourable starting-point for the solitary King. In this ending, as in others of the kind, a position in the centre of the board affords him the best chance of eluding his foes until their allowance of fifty moves is exhausted. This chapter, however, is written with great care and clearness, and the pawn endings in particular will well repay attentive study. The book concludes with seventeen "Examples of Master-play," which have been judiciously selected, and comprise some of the most brilliant games on record. Altogether Mr. Green is to be congratulated on having produced something that cannot fail to materially assist those who desire to master the initial principles of the game.

*Chess. By R. F. Green. London: George Bell & Sons. 1890.

## Contents of No. 52.


| | PAGE |
|---|---|
| On the Distances of the Fixed Stars. By A. C. Ranyard | 61 |
| List of Stellar Parallaxes. By Herbert Sadler | 63 |
| The Common Flea.—III. By E. A. Butler | 67 |
| Conchological Notes.—"The Operculum." By S. Pace | 69 |
| New Comet Identified. By E. E. Barnard | 69 |
| The Collotype Process and Photo-Engraving. By A. C. Ranyard | 71 |
| Some Properties of Numbers. By Robt. W. D. Christie | 72 |
| Walks in the Sydney Botanic Gardens. By C. Parkinson, F.G.S. | 73 |
| Photograph of the Sun's Surface. By A. C. R. | 74 |
| Notices of Books | 75 |
| Letters:—W. F. Ainsworth, J. W. Williams, R. O. M. | 77 |
| The Face of the Sky for February. By Herbert Sadler, F.R.A.S. | 79 |
| Whist Column. By W. Montagu Gattie | 80 |
| Chess Column. By W. Montagu Gattie | 81 |



## *TERMS OF SUBSCRIPTION.*

"Knowledge" as a Monthly Magazine cannot be registered as a Newspaper for transmission abroad. The Terms of Subscription per annum are therefore altered as follows to the Countries named:

| | s. | d. |
|---|---|---|
| To West Indies and South America | 9 | 0 |
| To the East Indies, China, &c. | 10 | 6 |
| To South Africa | 12 | 0 |
| To Australia, New Zealand, &c. | 14 | 0 |

To any address in the United Kingdom, the Continent, Canada, United States, and Egypt, the Subscription is 7s. 6d., as heretofore.

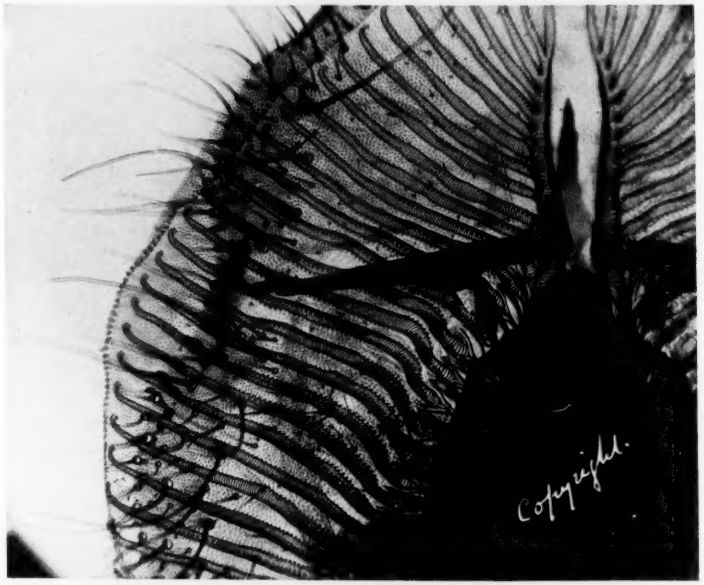
Communications for the Editor and Books for Review should be addressed Editor of "Knowledge," care of J. Malaby, 67 Chancery Lane, W.C.

XUM

Maxillary Palpi, proceeding from two cross-bars representing the Maxillæ. The heart-shaped piece consists of two fleshy lobes, each containing about 30 sucking grooves. When not in use, the lobes would be closed upon one another, but are here shown open to display their structure. Magnified about 40 diameters.

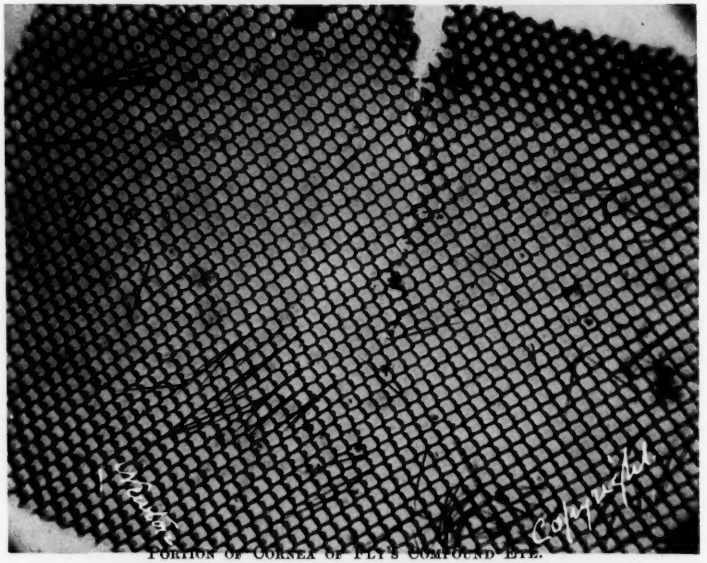
PORTION OF ONE LOBE OF EXTREMITY OF TONGUE OF FLY.

Showing chitinous curved rods in the sucking grooves, with their projecting ends giving a saw-like appearance to the edges of the grooves. Some forked teeth are seen at the base of the grooves. Magnified about 150 diameters.



PORTION OF FLY'S FOOT.

Showing last four tarsal joints, terminal claws, and adhesive pads. Photographed from above. Magnified about 50 diameters.



PORTION OF CORNEA OF FLY'S COMPOUND EYE.

Showing about 1600 facets, which are hexagonal in the centre, but become nearly square towards the lower edge. Only the transparent outer layer of the eye is here shown, but each facet has beneath it, in the natural condition, all the apparatus necessary to produce vision. A few hairs are seen, growing from between the facets.